# AN EXPLORATION INTO THE SCHOOL RELATED FACTORS THAT CAUSES HIGH MATRICULATION FAILURE RATES IN PHYSICAL SCIENCE IN PUBLIC HIGH SCHOOLS OF ALEXANDRA TOWNSHIP.

By

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**DECLARATION**

I declare that **AN EXPLORATION INTO THE SCHOOL RELATED FACTORS THAT CAUSES HIGH MATRICULATION FAILURE RATES IN PHYSICAL SCIENCE IN PUBLIC HIGH SCHOOLS OF ALEXANDRA TOWNSHIP** is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

SIGNATURE DATE

STUDENT NUMBER: 41492919

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# DEDICATION

**This study is dedicated to my son Pardon.**

## Abstract

The exploratory study investigated school related factors responsible for high matriculation failure rates in physical science in public high schools of Alexandra Township in South Africa. The target population included all Further Education and Training (FET) science educators and learners in Alexandra Township. An extreme-case sampling method was used to select a sample of two schools. Data was collected through two different closed questionnaires, one for educators (n=10) and the other for learners (n=250). The results were analyzed using mainly descriptive statistics.

The results, according to the views and opinions of educators and learners showed that the main causes of high failure rates are poor educator qualifications, outdated teaching methods, massive workloads, high levels of absenteeism and acute deficiencies in aspects related to: resources, subject content, classroom management skills, proficiency in language of instruction and assessment, motivation and perseverance.

Recommendations for practice and policy are suggested.

**Key Words:** Teaching sciences, learning sciences, aims of science, science education, science resources, causes of failure, achievement, skills and competences, mixed ability learners, motivation.

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# CHAPTER 1: INTRODUCTION AND BACKGROUND

## 1.1 Introduction

High rate of under-achievement in science at high school level is a cause of great concern across the globe (Fonseca & Conboy 2006:82). As a result, some nations, including the United States and Zanzibar, for example, have already started urging all citizens with special emphasis on schools, parents, industry, government and science communities to make a concerted effort against poor performance in science subject in high schools to ensure that future results would be more encouraging (Science Daily 1998: 1, Roach 2005: 1, Yussuf 2007: 1). It is disturbing to note that corresponding trends of low achievements in science have also been recorded in South Africa (Howe 2003: 1-15, Makgato 2007: 90-93, Govender 2009: 3).

The striking and central feature emerging from all these nations and others, indicate that under- achievement in science at high school level continues to be a major global challenge (Aldous 2004:65-70, Fonseca & Conboy 2006: 82-83, Kanyongo, Schreiber & Brown 2007: 37-43). It is therefore imperative to address this challenge for sustainable development, because each country's wealth and economic development is directly correlated to the capacity of its scientific workforce (South Africa 2003: 9, South Africa 2008: 8, Muwanga-Zake 2008: 1-2).

Although there are substantial global efforts to increase and improve the scientific literacy and the scientific workforce (Muwanga-Zake 2008: 1), it has however been recently realized that the science education systems are churning out less science graduates at all levels than the global economy requires (Cameroon 2009:15-16, Einhorn 2008: 2). It may therefore be logical to argue that the aforementioned decline in science graduates reflects a world-wide inability to succeed in science at secondary school level (Fonseca & Conboy 2006:82). Presumably, this as a result, could be a reason which has led to catastrophic skill shortages in science related fields, particularly in developing countries of Africa (South Africa 2008:1, Madibeng 2006:1-2).

The most common problem linked to learners' poor performance in science in most developed countries is mainly shortage of qualified science educators (Ruby 2006: 1007). Studies have associated shortage of qualified educators with lack of thorough preparation for lessons and reduced coverage of content (Howe 2003: 4-5, Ruby 2006: 1008-1009). In contrast, most developing countries including South Africa, have a host of factors ranging from lack of adequate science resources and facilities such as apparatus and laboratories, shortage of trained and qualified science educators, large science classes, limited proficiency in medium of instruction to outdated teaching methods as the central findings (Howe 2003: 1-2, Makgato 2007: 90, Mji & Makgato 2006: 259-261, Muwanga-Zake 2008: 4-6).

In South Africa, the mounting toll of failure in science persists to be an eyesore and a major concern at matriculation level especially in historically disadvantaged township and rural public high schools (Cameron 2009:16, Bloch 2008: 2, Gopal & Stears 2007: 16). It worries to note that underachievement in science in these schools is skyrocketing at an era when the ability to apply science is mushrooming and spreading out at an exponential rate to the daily lives and world wide events (April & Ahmadi-Izadi 2004: 1).

Subsequently, it may then imply that the underlying reasons for underachievement of learners in science at matriculation level, particularly in historically disadvantaged public high schools of South Africa, have not yet been sufficiently researched or appropriately treated.

Therefore, this study was designed to identify and analyze the school related factors that negatively affect performance of science learners at matriculation level in historically disadvantaged public high schools of South Africa with specific reference to Alexandra Township, in a more robust and interventional manner by obtaining information directly from Further Education and Training(FET) science educators and learners themselves since they are the ones involved in the teaching and learning of science. Furthermore, it intended to suggest ways of improving their performance and upskill the country's future scientific workforce.

## 1.2 Background

Development in South Africa faces a deepening crisis related to under-achievement in science at secondary school level (Cameron 2009:16). It is acknowledged that failure in science at matriculation level has a direct impact on the number of scientific professionals, and in turn on South Africa's development ( Madibeng 2006:1, South Africa 2008:9). It is possible to further suggest that high failure rates in science at grade 12 has orchestrated the subject to be an unpopular choice, resulting in fewer learners electing to take the subject at FET (South Africa 2008: 8-9). In addition, this has also caused acute shortages of scientific oriented professionals such as engineers, technologists, skilled artisans, technicians, doctors and chartered accountants (Mji & Makgato 2006: 254, South Africa 2008: 8-9). Consequently this has derailed development in South Africa (Madibeng 2006:1).

Available evidence from previous studies clearly reveal that the number of productive scientists and engineers in South Africa is nose-diving and is approaching a stagnant situation since the majority of scientists and engineers are aging whites (South Africa 2008:9). Perhaps the most eloquent testimony that reflects a closer relationship between under-achievement in science at grade 12 level and the number of scientific professionals produced in South Africa is provided by Spoelstra (2008: 1-2). His anecdotal evidence compares South Africa's production of scientists and engineers with other countries.

Drawing on international research, he indicates that South Africa is at the bottom of the hierarchy and produces 3.3 scientists and engineers per 1 000 people. In ascending order, it is followed by Brazil which produces 11.2 scientists and engineers per 1 000 people, then comes Australia which produces 32.5 scientists and engineers per 1 000 people. The United Kingdom produces 53.0 scientists and engineers per 1 000 people while Japan is on the highest level of the hierarchy, and produces 71.1 scientists and engineers per 1 000 people.

Analysis of the aforementioned data shows that South Africa produces far too few scientists and engineers per 1 000 people compared to developed countries. Although South Africa is directly below Brazil at the bottom of the hierarchy, further analysis of the data reveals a huge difference of 7.9 scientists and engineers per 1000 people between the two countries.

It is possible to deduce that fewer scientists and engineers in South Africa can be directly attributed to poor performance of learners in science at grade 12 which is the foundation and entry point for such professions. This can also be associated with the fact that learners are not motivated to enroll science as a subject at FET because they observe the high failure rates and are scared off and hence fear to jeopardize their grade average at matriculation level (Mji & Makgato 2006:257).

The number of scientists and engineers produced by the country is an important indicator of a country's scientific and technological infrastructure as well as its ability to make a contribution in the scientific and technological world (Bubenzer 2008:4). In other words, an army of adequate and well trained scientific workforce is pivotal to economic growth, social development and improved quality of life for all citizens (South Africa 2003: 5, Swain 2005: 4, South Africa 2008: 8). In a nut shell science is an instrument for sustainable development (Cameron 2009:16). Therefore South Africa faces major challenges of improving and increasing the human resource in science by enhancing the academic performance of learners in science at matriculation level.

### 1.2.1 Motivational Background To The Study

In its attempt to increase and improve the pass rate in science at matriculation level and ultimately build its human resource capacity in science, South Africa has developed a number of tangible initiatives and intervention programs at national and provincial levels and its higher educational institutions. Though not exhaustive, these include: the Dinaledi Focast Project, the Marang Centre by Wits University, the Sci-Bono Discovery in Newton, Technology Research Activity Centre (TRAC), and Mathematics, Science and Technology (MST) learning programs as well as Saturdays and holiday teaching of mathematics and science subjects (Cameron 2009: 16-18). In addition, South Africa has been recruiting qualified and experienced foreign science and mathematics educators to fill the gap of skill shortages as well as increase and improve the pass rate at grade 12 in these subjects (Chibaya 2007:1-3).

Furthermore, the government has also introduced science education to learners through the learning area of Natural Sciences in the General Education and Training band (GET) (South Africa 2002:1-2). The major aim is to catch talent at a young age and nurture it, with the hope of fostering and encouraging youth in pursuing science career pathways (South Africa 2008: 1-2). Science at FET band builds on the foundation laid by Natural Sciences at the GET band and then deepens the knowledge and skills already developed in the study of Natural Sciences (South Africa 2003:12).

However, it is disturbing to note that despite all the substantial favorable national efforts as noted above, the matriculation failure rates in science is still escalating and unacceptable, especially in black rural and township public high schools (Cameron 2009:16).

An analysis of matriculation results by population group based on 2003 database confirms that previously disadvantaged Black Township and rural schools still produce the highest numbers of failure in mathematics and science (Bubenzer 2008: 1).

Corresponding evidence is established from more recent results which shows that of the 724 learners who wrote science at matriculation level in Alexandra Township high schools in the year 2006, only a negligible 5.3 per cent passed science at higher grade ( The Star 2008:5). In South African context, a science learner should obtain 30% to pass science while 29% or less is considered as a fail (South Africa 2003: 61).

A further glance at the most recent matriculation results of the year 2008 reflects that poor performance of learners in science is a recurring problem and remains a major concern in most township public high schools of South Africa(Mayatula 2009:1-2). For example, a critical analysis of these examination results in Gauteng Province by districts shows that performance of learners in science in Alexandra Township is such a burning issue that needs further research in order to be addressed (South Africa 2009: 1). Table 1.1 provides evidence of an analysis of the 2008 average passes in science for the public high schools in Alexandra Township (South Africa 2009:1-2).

**Table 1.1**

**Average passes in science for all five public high schools in Alexandra Township for the year 2008**

| SCHOOLS | NUMBER OF LEARNERS WHO WROTE | NUMBER OF LEARNERS WHO PASSED | % AVERAGE PASS |
|---|---|---|---|
| A | 154 | 44 | 28.6 |
| B | 96 | 26 | 27.1 |
| C | 118 | 48 | 40.7 |
| D | 79 | 48 | 60.8 |
| E | 35 | 13 | 37.1 |

- School names are not included for ethical reasons.

It may be observed from Table 1.1 above that none of all the five pubic high schools in Alexandra Township managed to achieve an average pass rate above 62.5 % in the year 2008. In South African context any school that achieves a pass rate below the national average of 62.5% is called an underperforming school (Mayatula 2009:1).

Although this study was not concerned about results and examinations, it is worth pointing out that the achievement of science learners at matriculation level gives an indication of the effectiveness and efficiency of science teaching and learning in South African high schools (Mji & Makgato 2006 :256). The above information presents enough evidence of some deficiencies and gaps in the teaching and learning of science in public high schools of Alexandra Township. As a result, there was great need to carry out this study to investigate and unravel the shortcomings that are the chief causes of a comparative degree of under-performance of learners in science at grade 12 in predominantly African public high schools of Alexandra Township since science is the heart beat of the modern world.

### 1.2.2 The Township Profile

Alexandra Township covers an area of approximately 800 hectares.

#### *1.2.2.1 Geographical Location*

It is located 13 km to the north of the city of Johannesburg, and is bordered by industrial areas of Wynberg in the West, Malboro and Kelvin in the north, while Kew, Lombardy West and Lombardy East are all in the South.

Alexandra Township is dissected by Jukskei River and has three distinct areas, namely Old Alexandra, East Bank and Far East Bank (Tsutsumani). Old Alexandra stretches to the western side of Jukskei River and is characterized by densely packed shacks at the back of legal houses. East Bank and Far East Bank are both situated on the eastern side of Jukskei River. Along the banks and tributaries of Jukskei River, a lot of endless informal shacks have been erected.

#### *1.2.2.2 Demographic Profile*

According to the official statistics documented in the 2001 national census, Alexandra Township is one of the most densely populated black township in Gauteng Province with a population of 350 000 (South Africa 2008: 5). It is further stated that in Old Alexandra, and along the banks and tributaries of Jukskei River, the average population density is likely to exceed 1 000 people per hectare. Additionally, the statistics of 2001 national census reveals that in these areas, an average of around 8 people per household live in single roomed shacks.

The highest levels of illiteracy in Gauteng Province, has been reported in Alexandra Township (South Africa 2008: 6). It is also further revealed that people over 20 years of age have not received schooling while approximately 50 per cent of the people aged 5 to 24 are currently not schooling.

#### *1.2.2.3 Infrastructure*

Although the population of Alexandra Township is 350 000, the legal formal infrastructures were designed for a population of 70 000 people (South Africa 2008: 5-6). It is believed that continuous migration due to its proximity to employment opportunities in Johannesburg, Sandton and industrial sites of Wynberg caused the population to increase and resulted in the erection of illegal shacks most of which do not have electricity (South Africa 2008: 6).
There are 13 primary schools, 5 public high schools, 1 public library and 1 Technical College for the whole community of Alexandra Township. With regard

to high schools, Old Alexandra, which covers the largest area, has three public high schools while the fourth one is situated in East Bank and the fifth one in Far East Bank. Learners from the whole township and tremendous endless informal shanties that engulf the outskirts of the township attend their secondary education in five public high schools.

#### *1.2.2.4* ***Socio Economic Status***

According to Lauer and Lauer (2006: 22) socio-economic status refers to the position in the social system based on economic resources, power, education, prestige and lifestyle.

In Gauteng Province, Alexandra Township is considered to be one of the townships with the lowest level of socio-economic status because of a wide spectrum of problems. These range from lack of accommodation, overcrowding, unemployment, lack of educational facilities, high levels of illiteracy, violence and crime, large families staying in single dwelling shacks, lack of investment, to many workers earning an average monthly pay of low income category (South Africa 2008: 7).

Furthermore, orphans, grandmothers and single parents have been reported as primary care givers. It is possible to suggest that these factors, often in combination with poor sanitary conditions, make the living conditions extremely difficult in Alexandra Township for both learners and parents.

## 1.3 Purpose of This Study

Early research work established that students who fail in academic work had blocks in their path which may be social, economic, racial, gender, physical, psychological, emotional or a combination of all these (Oxenhorn 1972:35, Lancaster 1974:35). The major argument here was that any person in a classroom with some pressing problems might find it almost impossible to suppress the personal problems and concentrate or devote any attention to the intended learning outcomes.

However, the new dynamic and fluid image of looking at things acknowledge that a combination of both the home related factors (such as the parents' educational level, the family's income, single parenthood, orphan hood, violence and crime) and school related factors (such as the educator's qualifications, the educator's expertise, teaching and learning methodologies, language of instruction, availability of equipment and resources, classroom environments, organizational and management skills in classroom) influence rates of success or failure of learners at school (Donald, Lazarus & Lolwana 2006:196, Bennett 2007:246).

This study focused mainly on school related factors that cause high failure rates in science at grade 12 in public high schools of Alexandra Township. It took a holistic approach by considering a multiplicity of school interrelated factors such as inputs and processes that determine the relative effects on outputs or achievements ( Lemmer 2000:91, Howe 2003:4).

At independence, the South African government brought changes in its science and mathematics curriculum by overhauling and strengthening it with the view to establish a solid curriculum designed to respond to the needs of individuals and society at large (Bubenzer 2008:3). Another remarkable change was the number of learners doing science and mathematics subjects which were also increased drastically (Cameron 2009:17). Research acknowledges that change brings new challenges and that the new challenges faced may not be the same as before nor may not be less than before but may be actually exponentially more than before (April & Ahmadi-Izadi 2004:2).

In this regard, it may be possible to argue that a change in science and mathematics curriculum has put South Africa in a precarious educational predicament. This is because it has to increase the number of educators in these subjects which were already in critical shortage to meet the new demand and also improve the quality of few educators that already existed in these areas since Bantu Education System was generating semi-skilled educators to teach such subjects (Bubenzer 2008: 1-2, Bloch 2008:1-2). In addition, this created a need to increase the science resources which were already in massive strain in township schools to meet the new expansion (Dilotsothle, Smit & Vreken 2001:305). Therefore this study also intended to find out whether these and other challenges as reported elsewhere in South Africa affect performance of science learners at matriculation level in Alexandra Township using radically new and innovative research methods.

## 1.4 Research Problem.

With regard to the above, the research problem was formulated: What are the key causes of high failure rates in science at matriculation level in public high schools of Alexandra Township in Gauteng Province of South Africa?

There are many studies about learners who fail science at matriculation level, but this study intended to specifically answer the following questions:

- What are the school related factors that cause learners to fail science at matriculation level in public high schools of Alexandra Township?
- Which strategies could be suggested to improve the teaching and learning of science in township public high schools?

### 1.4.1 Research Aim and Objectives

The aim of the study was to investigate the key school related factors that causes high failure rates in science at matriculation level in township public high schools with specific reference to Alexandra Township, and to provide recommendations based on the findings. Furthermore, this would help policy makers, science educators and grade 12 science learners fulfill their academic potentials.

The objectives of this study were to:

- Determine the school related factors that cause failure rates in science at grade 12

- Ascertain the skills and competencies of both science educators and science learners to improve performance.
- Suggest strategies that could improve performance of both science educators and science learners.

## 1.5 Significance Of The Problem

The economic survival of South Africa depends to a large extent on the education and training of enough science learners at both secondary and post-secondary levels (South Africa 2008:12-13). This implies that science should prepare the matriculated learner for holistic development, socioeconomic development and environment management (South Africa 2003:9-10). Taken little steps further, science learning should instill in learners, a sense of responsibility towards challenges. These among others, vary from issues such as the control of pollution, health issues including the current scourge of HIV/AIDS and of H1N1 swine flu, change in climate, responsible utilization of resources within the environment to alternative use of energy as Learning Outcome three (LO3) in science curriculum states (South Africa 2003: 14).

Therefore the significance of this study was to identify school related problems and constraints that negatively affect science learners' performance in historically disadvantaged townships of South Africa. Evidence obtained could be used to rekindle the learners' interest in science as well as improve and increase their pass rate. This could ultimately increase the number of scientific orientated professionals.

Furthermore, the importance of the study was to come up with strategies of producing enough self-motivated science educators who are qualified to teach science at FET level, who have exposure to new teaching methods in science, who stimulate scientific curiosity in learners through direct investigations of the natural phenomena in their own immediate environments. This would also assist science educators to continuously seek new solutions to problems facing their science learners in the classroom. As a result, this may elevate the levels of teaching and learning of science in township public high schools.

Moreover, evidence obtained should encourage and motivate policy makers and curriculum developers to improve the quality, relevance and attractiveness of their science education so that it adapts to the needs of learners.

As circumstances with respect to science teaching and learning do not differ very much from township to township in South Africa (Dilotsothle et al 2001:305) due to the fact that they are all historically disadvantaged (Bloch 2008:2, Bubenzer 2008:1-2) it was assumed that the results of this study done in Alexandra Township could also serve a useful purpose in other townships of South Africa.

## 1.6 Limitations Of The Study

The study was limited to the public high schools in Alexandra Township where learners come from almost the same socioeconomic background and attend in public high schools with almost similar resources and infrastructure.

Furthermore, it was also limited to both FET science learners and science educators in public high schools of Alexandra Township.

## 1.7 Definition Of Terms

In this study certain concepts are used and need to be defined to clarify their use in this study. The definitions of these terms are theoretical assumptions for the purpose of this study only and may not cover all possible definition for the concepts.

**Active Science Learning:** For the purpose of this study it means that science learners construct scientific knowledge through physical and mental/hands-on and mind on activities by actively involved in problem-setting, problem-solving, dialogues and conversations with peers and the educator in rich environments(Shaffer & Kipp 2007 :288, Morrison 2009 :114).

**Curriculum 2005(C2005)**: The original and official name given to the post apartheid South African curriculum that focused on lifelong learning and was developed within the Outcomes Based Education framework which was phased out in the year 2006 because of some shortcomings (Aldous 2004: 65, Der Horst & MacDonald 1997: 243). The apartheid science curriculum had some gaps, bottlenecks, inequalities and was considered to be bias. Therefore the post 1994 curriculum was overhauled and strengthened with a view to establish a solid curriculum (C2005) designed to respond to the needs of individuals and society at large.

**Failure in Science**: For the purpose of this study it refers to lack of success, underachievement or underperformance of learners at grade 12 final exams in science (Webster's Third New International Dictionary A-K 1961:815).

**Further Education and Training (FET)**: This refers to the phase of education which starts in grade 10 and ends in grade 12 and learners choose the subjects they want to do which enable them to apply for a particular job or to enter an institution for higher education and training.

**General Education and Training (GET)**: In this study this refers to the phase that begins in Grade R and ends in Grade 9. This phase is believed to provide the learner with a general and basic education that is aimed at providing basic knowledge and skills that will allow the learner to move to different environments such as employment or further education and training. In other situations it includes Adult Basic Education and Training (ABET) levels 1 to 4(South African 2007: 157).

**Grade 12 / Matriculation Level**: In this study these two terms have been used interchangeably to refer to the final high school grade in South Africa, when after its completion, a learner can officially become a university student.

**Large Science Class**: According to this study a large science class is the one in which the learners per science educator ratio is very large such that the social and instructional aspects of the classroom environment are affected in such a way that it results in the educator unable to meet individual attention needs of each learner (Donald et al 2006: 141).

**Learning Area**: This term was used to refer to a unique field of knowledge with associated skills and values at General Education and Training band. The learning area that relates to the subject of science is the Natural Sciences learning area.

***Minima Naturalia***: This term was used in this study with reference to Aristotelian concept when describing small and indivisible particles in nature such as atoms, molecules, electrons, neutrons and protons, though they were not yet discovered and used by then (De Jong & Taber 2007:634)

**National Curriculum Statement (NCS)**: These are documents detailing the new curriculum in learning areas and subjects. The documents specify minimum standards of knowledge and skills to be achieved at each grade in all learning areas and subjects (South Africa 2003:3).

**Outcomes Based Education (OBE)**: An approach to education which forms the foundation for the curriculum in South Africa and in which outcomes are specified (South Africa 2003:2). Outcomes strive to enable all learners to reach their maximum learning potentials and provide targets that the educator aims to help the learner to achieve.

**Science**: For the purpose of this study, science refers to the subject of Physical Science that focuses on investigating physical and chemical phenomena through scientific inquiry by applying scientific models, theories and laws in order to explain and predict events in our physical environment

(South Africa 2003:9). In South Africa this subject is done as a choice at FET band and consists of chemistry and physics sections.

**Science Learner**: For the purpose of this study a science learner is a grade 10, 11 or 12 adolescent who is doing science as the subject of choice at the high school.

**Scientific Workforce**: In this study it refers to all persons that are scientifically literate and working towards the sustainable development of the country.

**Shortage of Scientific Skills** means that the country requires types of scientific skills in different sectors and departments that are not available in sufficient number to achieve the necessary coordinate expansion(South Africa 2007 :182-183).

**Skill** refers to the ability to perform a task or a group of tasks that is acquired. This may include physical skills (such as take a reading from a thermometer or the ability to use a micrometer screw gauge by a learner or an engineer when constructing a bridge etc) and mental skills (such as interpreting tables, equations or graphs). In other words, skill refers to the necessary competencies that can be expertly applied in a particular context for a defined purpose (South Africa 2007: 180).

**Skill Gap**: For the purpose of this study it refers to a situation where employment vacancies are unable to be filled in science related fields due to insufficient number of available workers with the necessary qualifications and expertise in science (South African 2007:181).

**Subject**: In this study the term was only used to refer to a unique field of knowledge and skills at FET level. In outcomes based curriculum a subject is broadly defined by Learning Outcomes, and not only by its body of content (South Africa 2003: 6). In other words, a subject is viewed as dynamic and always responding to new and diverse knowledge that integrates theory, skills, values and attitudes.

## 1.8 An Outline Of The Study

The focus and content of the subsequent chapters of the research study are as follows:

Chapter 1: Introduction and background: The general performance of science learners was discussed from a global point of view and was streamlined to the general performance of science learners in South Africa. This was further narrowed to historically disadvantaged townships of South Africa with specific reference to Alexandra Township which was the area of focus of this study. It went on to provide the necessary background to the study, research aims and objectives, relevance to the study, and definition of key concepts.

Chapter 2: Literature Review: The purpose of this chapter was to demonstrate how the research question fits into a larger field of study. It consists of literature review on theories and models of learning related to science.

Chapter 3: Literature Review on Previous research: This chapter focused and critically analyzed previous research on causes of failure in science in South Africa and elsewhere. Relevant books, government publications, journals, newspapers, magazines, websites, brochures and other information were consulted to support and explain the research question, the design and the data collection procedures.

Chapter 4: Research Methodology: Research designs and techniques were explained. The method of data collection, measuring instruments, the population, sample, participants, statistical tools and analysis were presented.

Chapter 5: Results and Discussions of Results: Data analysis and interpretation with regard to the results obtained from the questionnaire were presented and discussed.

Chapter 6: Conclusions and Recommendations: Conclusions were derived from the results. Recommendations and suggestions for improving the teaching and learning of science for better results were given.

## 1.9 Summary

This chapter elucidated the direct correlation which exists between achievements in science at secondary school level and sustainable development of the nation. It gave the background of the necessity of passing science at grade 12 as the foundation for building sufficient scientific oriented professionals in South Africa.

An overview of the underachievement in science at grade 12 in public high schools of Alexandra Township led to the development of the research questions, aim, and purpose of the study. Furthermore, it discussed the assumptions and outlined the format of the study. The next chapter focuses on the literature review by concentrating on theories and models of learning.

# CHAPTER 2: LITERATURE REVIEW: THEORIES AND MODELS OF LEARNING

## 2.1 Introduction

This chapter consists of literature review that discusses various factors that affect teaching and learning of science at secondary school level by mainly focusing at the theories and models of learning. The literature review aimed at identifying, clarifying and establishing factors and related issues that negatively affect teaching and learning of science at FET level which perpetually contribute to high failure rates at grade 12 in township public high schools of South Africa. It also looked at the theories of learning in relation to factors that contributed to the success of those learners who passed.

To assist in answering the research questions, the whole literature review was discussed with the South African science learner and educator in mind and in relation to OBE principles which forms the foundation for the South African curriculum.

There are many theories and models of learning with subtle differences and hence was impossible to be comprehensive in coverage. For the purpose of this study, much attention was concentrated on behaviourism, cognitive learning theories, social learning theories, constructivism, discovery learning theories and models, and the learning styles.

### 2.1.1 Why Learning Theories in Teaching and Learning of Science

Literature demonstrates the growing realization that most learning theories: have great value in the organisation of knowledge, have value in the direction of research for new knowledge, are used in the solution of problems, are of importance in understanding how children learn and hence facilitate teaching and learning processes in our daily situation and in classroom in particular (Berk 2006:264, Donald et al 2006:89, De Witt 2009:52, Morrison 2009:170, Mwamwenda 2004:170).

However, both history and contemporary research in these learning theories, suggest that they differ from each other in terms of how they view the learning process, the locus of learning, the role of the educator, motivational factors and learning outcomes (Morrison 2009 :114, De Witt 2009 :32, Shaffer & Kipp 2007:288). Therefore this chapter proceeded by comparing and contrasting some of the aforementioned learning theories and also provided suggestions with tangible and fruitful scientific examples, on how they can be applied in the teaching and learning of science at secondary school level.

Furthermore, the chapter also focused on how science educators may adapt to the teaching and learning approaches that borrow some elements from each of these theories in an integrated manner (Mwamwenda 2004:174). This is mainly because some characteristics of one type of learning theory may also be common to another type of learning theory (De Witt 2009:53, Daron, Branscombe & Byrne 2009: 16). In addition, research studies associated with these theories have shown that they have important influence on science teaching (Trowbridge, Bybee & Powell 2004:23).

## 2.2 Behaviorism and Science Learning

It is acknowledged, in behavioural view, that learning reveals itself only through observable behaviour (Daron et al 2009:150, Sternberg 2003:444). For example, Mwamwenda (2004:170) describes learning as a relatively permanent change in behaviour that results from what one has experienced, and that it may be shown in the way one thinks (cognitive), acts (psychomotor) or feels (affective). It is also believed that during learning, new behaviours themselves are learned and people's inner thoughts and feelings are only of importance if they are expressed in observable actions or affect their behaviours in some way (Morrison 2009:113, De Witt 2009:52). Therefore behaviourism, as may be concluded from the above, emphasizes overt behaviours that can be observed and measured.

Based on extensive historical researches, it is believed that behaviour is shaped by consequences, and the role of conditioning in the learning process is stressed (Daron et al 2009:150, De Witt 2009:53, Mwamwenda 2004:171). This implies that behaviourism attaches both classical conditioning and operant conditioning as the prototype of a large proportion of what the child learns daily such as learning of names of objects, events and language (Shaffer & Kipp 2007:187). Similarly, in science for instance, conditioning is also highly useful for early learning when picking up new chemical symbols of elements of the periodic table, chemical formulae of compounds, scientific equations, scientific laws and scientific principles.

However, classical conditioning and operant conditioning have been confronted with worldwide criticisms since both are believed to promote rote learning whereby learners recite the concepts over and over again (Trowbridge et al 2004 :47). New approaches to human learning do not favour rote learning and do not consider it to be meaningful learning since material learnt by rote learning cannot be integrated into the existing knowledge (Mwamwenda 2004:196, Kramer 2002:109).

Furthermore such traditional methods of teaching are educator-centred and emphasise on knowing rather than the process of knowing and imply a very limited approach. The educator is regarded as an expert in both scientific knowledge and scientific activities, who pours facts, information, concepts and demonstrates to learners how the world works rather than them (learners) discovering on their own (Trowbridge et al 2004 :5). Learning is also determined by the quantity of scientific knowledge prescribed and imposed by the educator and the quantity of scientific knowledge absorbed and recalled by the learner (Schneider, Krajcik, Marx & Soloway 2002:411).

Scientific concepts learnt in this way do not go far enough to explain advanced processes of thinking because the aim of science teaching and learning should be seen beyond the acquisition of scientific concepts and skills (South Africa 2003:9). In addition, such lower level of learning results only in memorisation of scientific facts, scientific rules, scientific laws, scientific principles and cramming of formulae without understanding science (Harlen 2000 :17). Learning of science occurs by investigation of the physical and chemical phenomena through scientific inquiry (South Africa 2003:10). De Witt (2009:53) describes conditioning as a passive form of learning since it only explains the connection between existing responses and new stimuli but does not provide explanation for the emergence of new form of behavior.

Nevertheless, it is very crucial for science educators to realize that real science learning occurs only when the learner is actively engaged in operating on, or mentally processing incoming stimulus, and that the interpretation of the stimulus depends upon previously constructed learning (Berk 2006: 239, De Witt 2009 :14).

However, science educators should not completely ignore learning by conditioning in their class but should not take it as the only way of teaching and learning during the lesson. Kramer (2002:110) shares the same view when he says that not all rote learning is useless since it may be necessary in other circumstances. For instance, learning of multiplication tables used for calculating problems in physics and learning of other big scientific terminology requires a learner to recite them over and over again in order to remember them. With this in mind, it may even be necessary to agree with Ausubel (in Kramer 2002:110) when he proposes that if after memorisation, learners are able to solve problems or apply the scientific principle to everyday situations (or correctly use the scientific terminology learnt by memorization), then this lifts the value of the exercise to one that is reception but meaningful.

### 2.2.1 Reinforcement in science learning

Additionally, behaviourists assert that the behaviour that is rewarded tend to be strengthened and is likely to be repeated while behaviour that is punished is weakened and reduced in future (Daron et al 2009:153, Donald et al 2006:104-105, Mwamwenda 2004:173-174). The role of the environmental stimuli in teaching and learning that produces changes in observable behaviour is strongly emphasised and is reinforced through a reward system determined by the educator (Sternberg 2003:9). Daron et al (2009:153-154) summarise learning as taking place under three variables namely:

- Stimulus(which causes behaviour)
- Response(the behaviour itself)
- Reinforcement(reward/punishment)

With regard to the aforementioned variables, learning can therefore be described as a process in which responses that lead to positive outcomes/behaviours or which permit avoidance of negative outcomes/behaviours are strengthened by means of rewards and punishments (Daron et al 2009:153).

In the classroom situation, the behaviourist approach emphasizes on the cause and effect (stimulus-response) which are measurable. In other words it stresses that learning results in a desirable change in behaviour of the learner such that the teaching methods and the learning materials chosen by the science educator for the lesson have great impact on the science learner. To be more precise, science educators should first ask themselves the kind of behaviours they expect in their learners from a science learning experience and then determine the reinforcers and the stimuli such as the environment, subject content, teaching methods, apparatus, motivation, rewards and experiments, and how the reinforcers can be best used in order to contribute in the best way to the behavioural change which the educator has in mind (Trowbridge et al 2004: 258).

Some authors cite reinforcement in some form of satisfaction after appropriate response as a way of motivating the learner (McKee & Phillip 2001: 7, Mwamwenda 2004:174, De Witt 2009:21). They claim that the reward system plays a very important role in educative environments such that a child who experiences recognition through acceptance learns behaviour more easily than the one who has had to learn it without acknowledgement.

The approval and rewards by the science educator may be regarded as methods of reinforcement of most of the learner's behaviour in class (De Witt 2009:53). However, the magnitude of the reward should vary from situation to situation. Among others these range from a fleeting smile by the science educator through a simple nod of the head, praise for good work, bringing the good work of a learner to the attention of others, a written statement on the learner's paper/workbook to a good grade.

In other situations, for instance, if the science educator notices a learner taking the reading correctly from the scientific apparatus during a group activity he may praise the learner or support the learner by asking probing questions in an interesting, challenging and curiosity-arousing manner. This is very useful for training or shaping skill performance in science because pleasant consequences or behaviour can be increased where a learner experiences positive reinforcement (Donald et al 2006:105, Fenstermacher & Soltis 2009:15). Research has shown that if a reward or reinforcement immediately follows the response to stimulus retention also becomes greater such that the response becomes more probable in future (Daron et al 2009:161, De Witt 2009:53).

In a nutshell, an effective science educator is the one who produces powerful gains in learner achievements by bringing about learning as a result of knowing precisely when and how to reward learners for the behaviours that increasingly approaches the goals set for them (Fenstermacher & Soltis 2009:19).

Not everyone agrees completely with the idea of reinforcement since it is believed to have some negative impact in other circumstances in class (Harlen 2000:44). For example, some negative comments or behaviour of the educator tends to reinforce the general trend of the learners' performance negatively. This may occur in class for instance, where the science educator keeps on discouraging a learner from demonstrating a task or avoid picking him to participate because on a particular occasion the same learner failed to perform a certain scientific task properly. In such a case the learner will then think that he is no good at the experimental task or in participating in class. Furthermore, the learner may think that he is not worth making an effort during the science lesson and then the feeling of being not good and incapable is reinforced such that the learner lacks effort and interest and eventually fails.

The educator's decision to give praise for correct work, recognition for proper behaviour and personally neutral criticism for incorrect responses all can influence academic achievement (Trowbridge et al 2004:26). In summation, if corrective feedback is properly given, it results in positive achievement and attitudes on the part of the learner.

Closely related to this, the classroom organization in which learners are grouped by ability during scientific activities leads learners to label themselves (Harlen 2000:46). The group of learners who always struggle may eventually lack interest in tasks assigned to them and hence negative reinforcement is instilled unconsciously by the science educator. Instead, the science educator may use mixed ability groups and attempt to build up self- confidence in such learners so that there is always motivation among members of the group and willingness to try. This as a result promotes chances of success.

In science learning, rewarding of a learner may also not be favoured to a certain extend, since this kind of motivation engages the learner in scientific activities for reasons of gaining approval of others and perhaps rewards that have little to do with scientific activities themselves (Harlen 2000 :46). Such a learner lacks the willingness to undertake scientific tasks, to persevere and to complete them yet development of scientific ideas by scientists depends upon a desire to understand and persist in natural phenomena until they are satisfied, rather than depending on rewards (South Africa 2003: 9). It is however possible to suggest that in such situations where rewards are used, science educators should encourage learners to take responsibility of their own learning so that they gain satisfaction and become self-motivated.

Bandura (in Sternberg 2003 :10) also criticizes direct rewarding of learners to a certain extend when he asserts that it is too limited because learning appears to result not merely from direct rewards of behaviour since it can also be social, resulting from observation (section 2.3.1 ) of rewards or punishments given to others. After all, behaviourists conducted their researches with laboratory animals such as rats and pigeons and hence the problem is whether such researches can be generalized to humans.

## 2.3 Cognitive and Social Learning in Science.

Alternative perspectives on learning comes from both cognitive and social learning theories which state that each person constructs his own meaning of things that he perceives (Donald et al 2006 :20, Kramer 2002 :6, Mwamwenda 2004 :192). However the two learning theories share some similarities and differences on how knowledge is acquired by individuals.

Both learning theories agree that learning results in cognitive development that involves qualitative changes in thinking as well as quantitative changes such as increased knowledge and ability, and that such changes make changes in behaviour possible (Berk 2006:259, Shaffer & Kipp 2007:282-283). They also share the same view that young children are curious explorers who are actively involved in learning and discovering new principles (Sternberg 2003:444).

However social learning theory views learning as a process whereby new knowledge is acquired when individuals from different social conflicts and points of understanding interact with one another (De Witt 2009:21). On the other hand, cognitive learning theory describes learning as a process of adjusting to new stimuli when individuals interact with their environments using their senses (Kramer 2002:6).

Unlike cognitive learning theorists who believe that knowledge is learned or constructed by children as they interact with objects in the environment (Berk 2006:220), social learning theorists assert that many of the discoveries that children make occur within a rich social context whereby co-operative or collaborative dialogues between a skillful adult or peer, models the activity and transmits verbal instructions (Berk 2006:263-264 and Shaffer & Kipp 2007:283).

Cognitive theorists focus at how individuals perceive various objects, learn, remember some facts and forget others, as well as how they think about information and solve everyday problems (Sternberg 2003:2, Morrison 2009:113). Its emphasis is on insights, thinking and meaningfulness of information by the use of senses (Mwamwenda 2004: 192, Sternberg 2003:445). In contrast, social learning theorists advocate that intellectual development results from a dialectical process of social interaction and language (Kramer 2002:9, Donald et al 2007).

Furthermore, it is believed that humans are continuously affected by their environment and always strive to discover order and interpret phenomena and recurring patterns in nature through a continuous process of learning (Berk 2006 :152, Shaffer & Kipp 2007 :249). In other words, people are seen as active and inventive throughout life that they construct their world by imposing order on raw materials provided by sights, sounds, smells and spontaneous contact and interactions with them.

This view sees children as capable of controlling their learning activities as well as organizing their field of operation since they have an inherent capacity to learn by interacting with their environment(Morrison 2009:115).

In his study, to examine learning achievement and experiences of science learners in a problem- based learning environment, Van Loggerenberg-Hattingh (2003:52) discovered that problem- based learning influences the learners' thinking much more than information that was read or told to them. He concluded that problem- based learning had potential to involve learners more and also made them more accountable for their own learning such that they had real understanding only of that which they invent themselves. This agrees with Piaget (in Charlesworth & Lind 2003:14) who had earlier on indicated that once adults interfere with children's learning, they keep them (children) from inventing and re-inventing things for themselves.

With this view in mind, science educators should allow their learners to spend more time in independent discovery-based activities in an environment which is inviting, challenging and motivating with a variety of learning materials so that they can interact with the materials using all their senses (Berk 2006 :152, De Witt 2009:13, Shaffer & Kipp 2007 :288). In other words, science teaching and learning must be characterized by an emphasis on active learning whereby the learners are seen to be active in scientific investigations in a classroom environment full of different materials and unfamiliar activities to them since learners do not waste time attending to completely familiar activities (Trowbridge et al 2004:24). Science learners should therefore be presented with problems that provide them with opportunities to engage in thinking, insights and problem solving as an integral part of their science lessons.

Social learning strongly asserts that human cognitive development is inherently socio-cultural such that it is influenced by beliefs, values and tools of intellectual adaptation passed to individuals by their culture (Shaffer & Kipp 2007 :284, Kramer 2002:7 ). It believes that children's mental, language and social development is supported by and enhanced through such social interactions.

Children are therefore seen as seeking out adults for social interactions beginning at birth and that a variety of developmental processes occur through these interactions (Morrison 2009:121). This radical and dynamic view of learning emphasizes that children learn much more by social interactions with parents, peers and educators and hence develop new ideas, skills, values and attitudes (Mwamwenda 2004 :185, Shaffer & Kipp 2007 :281).

This same view of learning favours guided participations in science class whereby the science educator structures the learning activities, provides helpful hints or instructions while he monitors the progress of learners (Shaffer & Kipp 2007:289). This implies that, in order to assimilate and accommodate the effects of constant change at each stage of development, the science learners need continued accompaniment and assurance from the science educator and peers (Charlesworth & Lind 2003 :14, De Witt 2009:41, Trowbridge et al 2004:23).

### 2.3.1 The Zone of Proximal Development (ZPD) in Science Learning

According to Donald et al (2007:61), Vygotsky proposes of the Zone of Proximal Development (ZPD) which refers to the area where the child cannot solve a problem alone but can be successful under adult guidance or in collaboration with a more advanced peer so that he acquires and integrates the new knowledge into his existing knowledge.

For example, in science, a grade 12 learner may understand vertical motion since he would have treated the concepts of linear motion in grade 11. This implies that tasks below ZPD the learner can learn independently such as calculations that involve equations of linear motion. However, scientific tasks, scientific ideas and scientific information above the ZPD, the learner is not yet able to learn even with help (Berk 2006: 260).

Tasks or activities such as: "Evaluation and calculations of 2-D projectile motion" are above the grade 12 learner's ZPD. Literature has shown that the learner can complete such tasks with the help or guidance of the science educator by means of communication and dialogue to assist the learner grasp concepts and think his way to a higher level concepts (Morrison 2009: 123). Shaffer and Kipp (2007:283) advise educators to use sensitive instructions at this stage for new cognitive growth to occur. Such assistance by the educator or a more skilled partner in the ZPD, where, for example, a grade 12 learner can now complete tasks of calculation of 2-D projectile motion as a result of guidance and encouragement which he could not complete independently is called scaffolding (Charlesworth & Lind 2003:14, Sternberg 2003:461). It is considered to be a major component of teaching (Shaffer & Kipp 2007:284, Morrison 2009:123).

When a science educator assists a learner in developing an understanding and the calculations of 2-D projectile motion, he is scaffolding him from not being able to understand and calculate, to being able to understand and calculate (Morrison 2009:122). The science educator should provide instructional assistance or scaffolding for a learner during the mathematical calculations of 2- D projectile motion. In other words, the science educator guides or supports the learner's understanding and calculation by building on what he is already able to do from vertical motion, moving him to a higher level of understanding and calculations of 2-D projectile motion. This is in line with the new South African curriculum which sees the educator as a facilitator or mediator of learning (South Africa 2003:4).

The first step in scaffolding is for the educator to identify the learners' level of development and then assist by presenting learners with resource materials that is a little more ahead of development as well as providing appropriate instructions (Hammill & Bartel 2004:215). Learners should be engaged in step by step process starting with specific information until they reach major concepts (Morrison 2009:123, Shaffer & Kipp 2007:285). This implies that the educator should see scaffolding as a gradual process of providing different levels of support such that it is concrete and visible at the beginning, till it moves to an abstract and slowly withdrawn when the task is mastered.

### 2.3.2 Promote Co-operative and Collaborative Tasks

Research has shown that the learner's concept of his physical world is a function of the special and unique interaction between the learner himself, the educator, others, the environment, experiences, needs and ideals (De Witt 2009:32, Morrison2009:122). Therefore science educators should create positive social-culture environments by arranging cooperative and collaborative learning tasks in which learners are encouraged to assist each other to perform scientific activities (Shaffer & Kipp 2007 :288). The idea here is that less competent learners in the teams are likely to benefit from the instructions they receive from their more skilful peers who also benefit by playing the role of their educator.

Further research has also shown that as learners proceed with scientific activities in collaborative and co-operative small and mixed groups they have a variety of ways to interact among themselves (Mwamwenda 2004:192, Shaffer & Kipp 2007:288). It is further established that the combined range of abilities and scientific knowledge that individual learners bring to the learning process, promote a rich learning environment that provide learners with opportunities to construct their own relationships, communicate, share ideas, share tasks, argue, debate scientific issues, learn how to accomplish scientific tasks and solve problems by working together and gain deeper understanding of reality (Charlesworth & Lind 2003:5).

Vygotsky (in Morrison 2009 :122) emphasizes the concept of inter-subjectivity where by learners in a science class for instance, come to a scientific activity or scientific problem with their own subjective ways of making sense of it such that if they are allowed to discuss their different viewpoints, a shared understanding may be reached. In such cases they have an opportunity to explain their ideas to each other as well as have access to the views of others but at the same time retain ownership of their own developing understanding (Harlen 2000 :24). As a result, this motivates learners such that they may become more likely to use high quality cognitive strategies to solve a variety of scientific problems.

In other words, learners' ideas are influenced by those of others and the ideas are constructed on the basis of social and educational interactions as well as their own thinking (Harlen 2000:24). Through becoming aware of others' ideas and sharing their own, learners negotiate meaning for their experiences and for the words that are used to communicate them (Harlen 2000:25).

Viewed from a different perspective, this may imply that as learners interact with the other peers during these scientific activities, a learner with a grasp of one scientific aspect may mediate another to a higher level of understanding. This supports the view of Vygotsky(in Kramer2002:9) when he says that teaching should be an act of helping learners to move from where they are(within their zone of existing knowledge) into a place of new expanded knowledge(their zone of potential).

Although this view is the opposite of the Piagetian perspective which sees children as much more solitary developers of their own intelligence and language by interacting with their environment both views are very crucial and can however be integrated in the teaching and learning of science (Morrison 2009 :122).

### 2.3.3 Social- Observational Learning in science.

While Bandura (in Mwamwenda 2004:185) shares the same view with other social learning theorists with regard to the above mentioned aspects, his different perspective on how learning occurs is worth mentioning and considering in the teaching and learning domain. He believes that an individual determines his own behaviour and development while being influenced by environmental factors as well as by his own behaviour. He further states that behaviour is learnt mainly through environmental influences particularly social influences that involve observational learning, symbolic processes such as thinking and expectations, self regulatory processes such as planning and arranging the environment and the individual’s evaluation of his own behaviour (De Witt 2009 :30).

According to Bandura’s social learning theory which is also called the observational learning theory or modeling theory, children learn a multitude of a variety of new social responses by observing the actions of salient models around them such as parents, playmates, siblings, educators, TV heroes or even the story book characters and then store them in the form of mental images or symbolic representations (De Witt 2009:30).

In this regard, it may imply that humans are social beings that acquire knowledge and skills through observational learning whereby they consciously observe others and imitate them (De Witt 2009:55). This means that visual learning, laboratory demonstrations, role play, videos and modeling are important teaching strategies and may be incorporated in science teaching to assist learners to acquire and develop scientific skills and knowledge(Lemmer, Meier & Van 2006:76, Trowbridge et al 2004:28-31).

For example, if a learner observes how the educator or the peers connect the electrical components in a circuit correctly during a demonstration, then by imitating them he develops similar skills and knowledge(De Witt 2009:55).

This view tends to agree with Vygotsky (in Harlen 2006:461) who emphasizes the importance of others (adults and peers) in the child's environment. However, for Vygotsky, instruction must play a major part in the child's learning while for Bandura observation which is followed by imitation is very crucial for the child to learn (De Witt 2009:41). However both theories are very important and may be integrated in the teaching and learning of science (De Witt 2009:29- 30).

## 2.4 Discovery and Reception Models of Learning in Science.

Discovery model of learning emphasizes that the learner learns best when he himself discovers the structure of the subject through inductive reasoning and intuitive thinking (Donald et al 2006:85-88, Mwamwenda 2004:192-193). Like cognitive learning, this model also views the learner as an active explorer and strategist who is capable of discovering new information independently(Kramer 2002:6-7, Donald et al 2006:85, Berk 2006:251, De Witt 2009:221).

However, discovery learning involves the learner coming up with knowledge by one's self that involves rearranging or transforming evidence so as to obtain new information or insights (Mwamwenda 2004 :192-193) and does not necessarily mean coming up with knowledge that is unknown to anyone else as cognitive learning suggests(Sternberg 2003 :446, Harlen 2002 :6 ).

Discovery learning is very important during a science lesson since it calls for active participation of the learner and hence the learner can retain information which he discovers for himself for a longer period of time. In addition, South African curriculum which follows the principle of OBE is based on discovery learning as it emphasises on what the learner learns rather than what the educator can impart (South Africa 2003:2).

Basically the teaching of science through discovery methods provides opportunities for learners to experiment, to investigate problems, and to work in groups. This enables them to discover scientific concepts and principles for themselves instead of educators revealing them to learners. Furthermore, they learn how to investigate problems, propose and argue solutions as a community of young scientists.

Since discovery learning is a problem- centred approach, it brings about some cognitive conflicts in the learners' minds as they experiment and try to search for scientific solutions (Schneider et al 2002:412). Cognitive conflicts promote in learners, development of problem solving skills and the ability to think and act in ways which are associated with inquiry (Harlen 2000:17). Inquiry promotes process skills such as observation, asking questions, hypothesizing, planning, conducting investigations, use of appropriate tools and techniques to gather data, think critically and logically about the relationships between evidence and explanation, construct and analyse alternative explanations and communicating scientific evidence(South Africa 2003:13).

Rather than learners being taught factually as passive receivers, recent studies have shown that scientific inquiry also provides them with opportunities to share their own ideas, develop art of communication, share responsibilities and co-operate in effective team work in such a way that they become familiar and confident in handling apparatus (Flick & Lederman 2006:5, Van Loggerenberg-Hattingh 2003:53-56). Through such interactions, their reasoning ability becomes more explicit and result in extensive cognitive development (Schneider et al 2002:414).

However, a more contradictory opinion, comes from Ausubel's reception model, which stresses that learners acquire knowledge primarily through reception rather than through discovery (Donald et al 2006 :194, Kramer 2002 :109, Mwamwenda 2004 :194).

In reception learning for instance, science learners should be presented with all possible information on a given science topic in its final form. (Mwamwenda 2004:195). For example, if the science class is looking at the concept of magnetism, the reception model suggests that the educator should provide learners with all information or concepts about magnetism including information such as: like poles of magnets repel while unlike poles attract or the magnetic force is concentrated at the poles of magnets rather than giving them magnets at first to find out what happens by bringing the poles of the magnets close to each other or giving them iron filings to determine the area of the magnet with greater force on their own.

However, Ausubel (in Kramer 2002 :109) further advocates that teaching and learning should involve advanced organizers where the educator may use details such as models, diagrams, charts, illustrations or pictures. The use of such advanced organizers in science is very crucial because they assist learners to assimilate and accommodate scientific concepts.

Advanced organizers may also be an introductory statement of relationships between two or more variables, for example, such as, "Like poles of magnets attract while unlike poles repel".

It should be noted that the reception model is not completely against practical activities, whereby learners find the relationship between the two poles of the magnet practically, but it emphasises that learners should explicitly have full information and understanding of the relationship between the poles as well as all the necessary information and concepts before they are engaged in practical activities so that they gain clear idea of what they would be trying to prove in the practical activity. This makes it easier for them to relate the information they will have learnt to the relationships under investigation which can lead them to make deductions, plot graphs and derive mathematical formulas if required.

Like Vygotsky (in Morrison 2009:114) who sees language as a powerful tool of intellectual adaptation and the primary vehicle through which adults pass culturally valued modes of thinking and problem solving to their children, Ausubel (in Shaffer & Kipp 2007:289) also emphasizes the use of meaningful verbal learning whereby most of what is learned in the classroom is based on the use of language as a means of communication. Therefore, science educators should use simple and clear language of communication which can be easily understood by every learner when teaching science (De Witt 2009:20).

## 2.5 Constructivism in Science

Constructivism asserts that learners' cognitive structures actively build or construct new knowledge based on what they already know or can do by interacting with their environment in an attempt to make sense of the world (Berk 2006 :221, Donald et al 2006:52, Shaffer & Kipp 2007 :250). This implies that learners do not learn things in isolation from what they are already familiar with.

According to Piaget (in Kramer 2002:7, Shaffer & Kipp 2007:250-251) each individual is born with some sort of collection of knowledge, skills, and values called schema. For Piaget (in Shaffer & Kipp 2007:251), cognitive development is development of schema or structures which are the means by which a person interprets and organizes experience.

In constructivist model, it is therefore believed that when a learner learns something new he builds or constructs it on top of what he already knows to fit the new learning and the old learning in a balanced way (Shaffer & Kipp 2007 :250, Sternberg 2003 :449, Morrison 2009 :116). Hence, from the constructivist's point of view, learning may be best described as an active process in which children and adults construct their own personal meaning of the objects and events through interactions with them by incorporating new information into prior knowledge, experiences, episodes and images (Shaffer & Kipp 2007 :249, Morrison 2009 :114, Trowbridge et al 2004:23). In other words, for meaningful learning to take place a set of an individual's information should be related to the past, present and the future experiences.

It may therefore be possible to conclude that acquiring knowledge involves personal construction of meanings and many informal theories that an individual develop about the natural phenomena (Sternberg 2003:446, Donald et al 2006:53). Furthermore, it may be presumed that knowledge is a result of constructive activity and exists in the mind of the cognising being where it is constructed or built and cannot be transferred to a passive receiver (Shaffer & Kipp 2007:250, Morrison 2009:113).

### 2.5.1 Science Learner and Prior Knowledge

De Witt (2009:52) sees learners as the prime movers and active participants in the construction of scientific knowledge within the teaching and learning domain. This view is in contrast to the traditional approaches to education that presumed learners as passive recipients of the learning process who would wait for their educators to put or pour knowledge directly into their heads like an empty vessel that need to be filled up with liquid and expect them to merely repeat information in textbooks or transmitted to them by educators (April & Ahmadi-Izadi 2004:53).

In light of the above, science educators in classes need to realize that they are not dealing with blank minds, but are working with learners to conform, modify, replace and add to what is already in their minds (Berk 2006 :220, Sternberg 2003 :11). Similarly, their effectiveness and efficiency in teaching science is related to the learner's prior knowledge of the related material (Hammill & Bartel 2004:213). Therefore they need to establish the learner's prior knowledge before they plan for the lesson. This implies that the learner's prior knowledge is very crucial for the teaching and learning process.

Ausubel (in Kramer 2002:116) had long expressed the same view by saying, "the most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly." In this regard, what the learner already knows about the science topic as he comes to the lesson is very important and acts as a platform upon which he builds new scientific concepts. Hammill and Bartel (2004:215) further emphasise the same point differently by saying that knowledge is hierarchical such that learners are ready to learn scientific concepts that are just beyond the level of the concepts they have already mastered (prior knowledge) in such a way that each new understanding is built on, and must be assimilated into, prior understanding of relevant information.

It is therefore the responsibility of the science educator to apply both formal and informal assessments since both complement and supplement classroom teaching and learning (Linn & Miller 2005 :25) to determine the learner's prior knowledge, experiences, misconceptions and interests (Trowbridge et al 2004 :257).

It may be suggested that once prior knowledge is established, the science educator may turn the prior knowledge of learners into fruitful resource of learning by planning accordingly and giving learners an opportunity to actively construct knowledge through experiencing things and reflecting those experiences, and not act passively from the environment.

For example, a grade 10 science learner who is familiar with neutralization as the reaction between acids and bases that results in products such as salt and water may receive new information on balancing chemical equations that involve acid- base reactions. The science educator should assess to find out if the learner has the background information about the acid- base reactions (neutralization process) before he introduces the concept of how acid- base equations are chemically drafted and balanced. The meaning of the new information about balancing acid-base chemical equations will be interpreted and understood under the higher order concept and principle already known by the learner about the neutralization process (acid-base reaction).

In such a situation as described above, whatever new information the learner acquires such as conjugate acid- base reactions that involve calculations of the number of moles of salt and water produced by reacting given masses of a base and an acid can be related to higher order scientific concepts and principles already existing in the learner's cognitive structures.

### 2.5.2 Address Misconceptions By Promoting Cognitive Conflict.

Constructivist research identified that learners' conceptions about scientific phenomena differ from accepted scientific conceptions or perspective (Trowbridge et al 2004:23, Scott, Asoko & Leach 2007:35). In other words, their initial knowledge, which they bring to the classroom that make sense to them based on daily life experiences and expressed in everyday language may not match the science context and hence may be wrong (misconceptions).

Interestingly, further critical analysis of literature has shown that such personal theories of learners which are incompatible with scientific views may not be easy to give up especially in the process of teaching and learning of science where the learners' pre-instructional conceptions about phenomena are deeply rooted in everyday experiences (Trowbridge et al 2004:23). Duit, Niedderer and Schecker (2007:599) strongly believe that this difficulty in conceptual change is normally compounded by the fact that:

- Science (especially the domains of physics and chemistry) is abstract and highly idealized kind of discipline which involves mathematical modeling,
- The abstract character of science (physics and chemistry) concepts requires formal reasoning and knowledge of phenomena and this is not easy for many learners who tend to see atoms, molecules, electrons, protons and neutrons as ***minima naturalia*** (De Jong & Taber 2007 :634) instead of theoretical model concepts. In addition to this, some learners may not have reached the formal operational reasoning that requires abstract thinking since human cognitive development theory asserts that formal operational stage is attained at different ages or may not be reached at all by some individuals (Sternberg 2003 :446, De Witt 2009 :20, Saunders & Shepardson 1987 :39-40),
- Science (physics and chemistry) is greeted with the lowest interest by most learners because of its nature (mathematical nature), particularly by girls and hence may resist change(Duit et al 2007 :607),
- Science (physics and chemistry) is perceived by learners as complicated, difficult, and counterintuitive and incomprehensive. For example, in quantum physics and relativity, the physics view is incomprehensible in the principle from everyday world perspective (Duit et al 2006: 606-607),
- Most science educators do not pay much attention to learners' everyday conceptions of physical and chemical phenomena when teaching both physics and chemistry (science ) such that learners consider chemical reactions and physical processes as other formal processes while chemical equations or equations in physics are considered to be algebraic expressions ( Duit et al 2007 :634).

These views taken together, imply that it is very crucial for science educators to recognize the learners' current misconceptions and convince them that their own theories are incomplete, inadequate or inconsistent with experimental evidence and that the scientific explanations provide a more convincing and powerful alternative to their own ideas (Trowbridge et al 2004: 23, Scott et al 2007:36-37). In addition, the science educator should link such conceptual change in the learner to the process by which scientific theories undergo change and restructuring (Trowbridge et al 2004:24). All this can be achieved by presenting learners with concrete experiences.

Literature has further shown that to facilitate learners to go through a difficult process of conceptual change in physics and chemistry science educators should introduce information to see how learners apply to their prior knowledge by simply engaging them in additional experiences that challenge, refute, or extend their own existing ideas while they guide them to question, experiment, discover, discuss, argue, solve problems for themselves, construct, revise and test new ideas against previous ideas and to make conclusions (De Witt 2009:221).

Such active and explorative processes where the learner is given opportunities to try things out should be designed in ways that involve practical activities that promote the learners' interaction of all five senses with events and objects so that there is a personal construction that fits some of the external reality but does not provide a match (Kramer 2002:7-8, Donald et al 2006:52). Studies have shown that when the learner comes across such discrepancies in his own knowledge, or discover that knowledge and cognitive structures are insufficient to cope with the stimuli from the environment, he will be motivated to adapt and change his own thinking in order to achieve a state of equilibrium once again (Berk 2006:152, De Witt 2009 :14).

Sternberg (2003:448-449) supports the same view but however emphasizes on practical activities during the lesson which he believes in creating enough cognitive conflicts (disequilibrium) or dissatisfaction with the learner's present beliefs to abandon misconceptions and promote old schema (old information) and new schema (new information) to adjust, reshuffle and reshape so that they make sense to the learner.

While others fully agree to the idea of promoting disequilibrium and active construction of knowledge during a science lesson, they however add a further dimension by stressing that educators should use various strategies that may complement hands-on and minds-on activities (Harlen 2000:5, Charlesworth & Lind 2003:472). These may include for example, learners handling apparatus, mind mapping, brainstorming, having learners verbalise their thoughts during problem solving in a rich and conducive environments. All this triggers the learners' innate curiosity about the world and how things work such that the learners become eager and ready to explore.

Ultimately this challenges and supports them to learn well by using discrepancy events that put them in disequilibrium such that they develop an understanding of the real world by applying their existing knowledge and experiences to hypothesise, test theories and solve problems in the process of building new and more advanced scientific knowledge.

This process whereby the cognitive structure is adjusted in such a way that unknown and new objects and experiences are fitted into the cognitive structures so that the learner copes better with his environment is called accommodation (De Witt 2009: 54, Shaffer & Kipp 2007 :251). Thus the learner changes his cognitive schema in order to fit in those aspects which do not fit properly.

In other words, the cognitive conflict challenges the learner to modify his whole mapping structures in order to equilibrate (Donald et al 2006:5).

Kramer (2002:8) proposes a constructivism model that shows how the processes of assimilation, equilibrium/disequilibrium and accommodation are achieved during cognitive development.

Figure 2.1 below illustrates Piaget's constructivism model of equilibrium. All words in italics are added to elaborate the example of free falling objects in physics such as two falling stones of different masses.

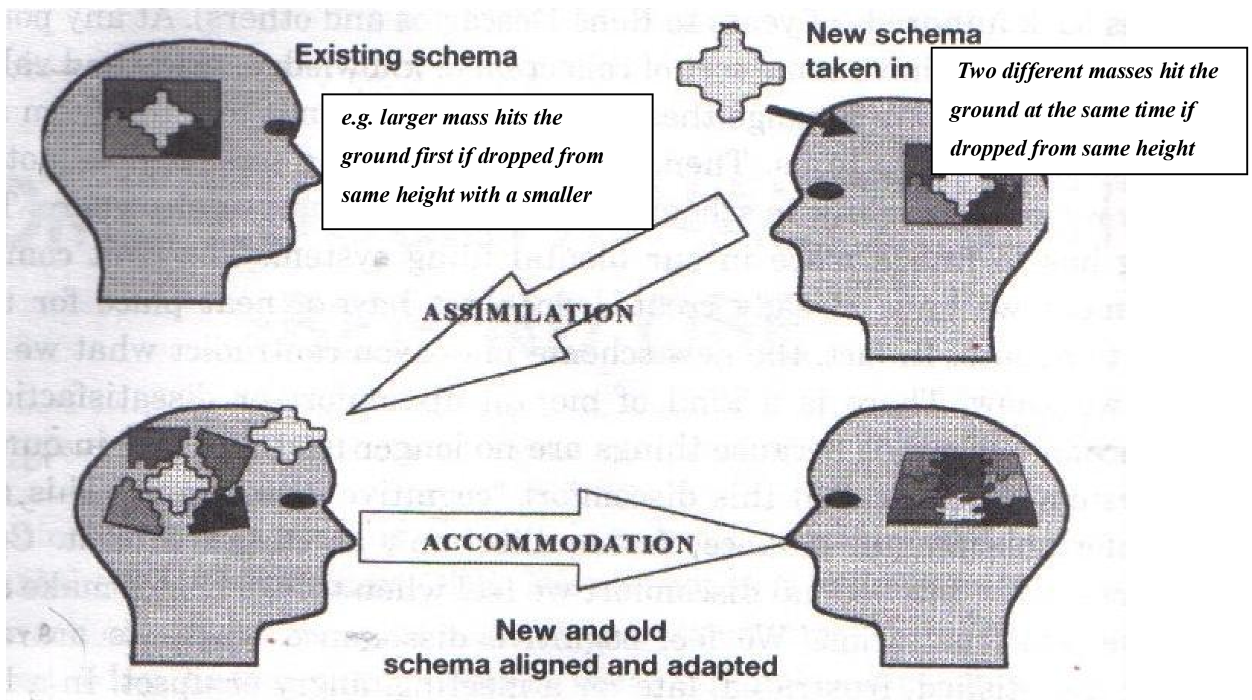


**Fig 2.1: Piaget's Constructivism model of Equilibrium: Source: Kramer (2002: 8).**

There are three possible main points that educators should remember from Piaget's constructivism model of equilibrium as illustrated in fig 2.1 above:

- Learners build or construct new knowledge and skills based on what they already know or can do.
- Learners adjust what they already know to fit the new knowledge and the old knowledge together in a balanced way.
- Teaching and learning experiences should be designed to give the processes of assimilation, disequilibrium and accommodation to function.

## 2.6 Accommodate Individual Differences in a Science Class

Modern researchers have indicated that a normal class has learners that are unique from each other in terms of cognitive developmental levels, home languages, intelligence, prior knowledge, learning styles, ways of solving problems and perceiving things, culture, socioeconomic background, ethnic background, parents' educational levels, family and community attitudes just to mention a few (Kramer 2002:12, Lee & Luykx 2006:13, Norman, Ault, Bentz & Meskimen 2001:1101). It is therefore very crucial for the science educator to take into consideration the heterogeneity among his learners and focus more energy on an attempt to understand the learner as an individual and then plan activities for individuals and not for the whole class (Berk 2006:251). Hence it may be further argued that the teaching material, teaching style or method that is appropriate for one learner will not necessarily be appropriate for another (Kramer 2002:12).

### 2.6.1 Learning Styles

Learners, like other individuals have different learning styles that affect their way of thinking, how they behave, how they approach learning and how they process information (Rief & Heimburge 2006:11).

Learning style is described as the way the learners of every age are affected by their immediate environment, own emotionality, sociological needs, physical characteristics and psychological inclinations when concentrating and trying to master and remember new or difficult information or skills (Morrison 2009 :435, Rief & Heimburge 2006 :12). For example, some learners work well in groups, others prefer to work alone; some need quiet in order to concentrate while others cope with noise and movement.

In this regard, research studies have established that learners learn best in classroom environments that are compatible with their own learning styles (Lemmer 2000:68, Schneider et al 2002:413-414). Some learners do not succeed as well as others in class if they are not given the opportunity to use their own learning styles and hence academic achievement is enhanced where educators accommodate different learning styles and preferences of learners (Norman et al 2001:1106).

It may therefore, be necessary to suggest that awareness of and sensitivity to the needs, attributes and learning styles by science educators assists in teaching diverse science learners in the classroom ( Kramer 2002:12, Morrison 2009:435, De Witt 2009:221). In other words, if educators understand individual learning styles they can plan instructional methods, prepare learning activities and organize the learning environment accordingly in order to make learning more relevant and effective for each learner.

Although each learner has his own learning style, it however does not mean that the learner only learns through that particular way (Reif & Heimburge 2006: 12). It is the way through which the learner learns best or finds it easier to learn and process information (Kramer 2002:12-13). In this regard, the educators can cluster learning styles for instructional purposes (Morrison 2009:434). He also needs to realize that there is no right or wrong way to learn, but instead assists to provide support and opportunities each learner requires in order to have equal chance to achieve success(Rief & Heimburge 2006 :11).

Extensive literature has identified the sensory channels or modalities of visual, auditory, kinesthetic and tactile as the commonly used learning styles in most classrooms (De Witt 2009:52, Morrison 2009:435, Kramer 2002:13, Rief & Heimburge 2006 :12-13). A critical analysis of this literature indicates that:

- *Visual learners* learn best by seeing, watching and observing and are therefore, very strong in remembering visual details through pictures, images, graphics, and information written using different bright colours for them to refer (Reif & Heimburge 2006:13). To promote successful science learning, educators are advised to use a wide variety of visuals in class such as charts, posters, models, pictures, science equipment, chemicals, DVDs, computers, power point, cards, different objects for learners to observe and key scientific words or scientific phrases which are accompanied by verbal presentations and directions (Trowbridge et al 2004:27-32).
- *Auditory learners* prefer spoken messages and learn best by listening and verbalizing (Rief & Heimburge 2006:12). In such circumstances, the science educators should encourage and provide opportunities for oral presentations, debates, discussions, radios, videos, films and create sessions for question and answer (Trowbridge et al 2004:29).
- Both *Kinesthetic and tactile learners* learn best by doing, touching, smelling, moving, and assembling objects and direct involvement (Rief & Heimburge 2006:13). In other words, these learners want to sense the position and movement of what they are working on and hence are hands-on learners

who need to be involved physically with activities (Trowbridge et al 2004:29-31).

Further research on learning modalities has shown that providing similar opportunities and learning styles to such learners makes some enjoy the lesson and do well, while others struggle and perform poorly all the time (Charlesworth & Lind 2003:14, Kramer 2002: 14). Hence science educators should plan with each learner in mind, choose familiar contexts and provide activities that capture learners' diverse interests as well as create a multi-sensory classroom environment to accommodate all learning modalities (Trowbridge et al 2004:343-344).

Morrison (2009:435) adds a further dimension by suggesting that educators should create conservation areas or an activity-oriented learning environment separated from learners who need for example, quiet or silent areas, or who need to subvocalize (read aloud to themselves) or those who prefer moving about as they learn and those who may need more light.

Kramer (2002:24) adds a flavour to the same view by saying that all learners can succeed if they are allowed to learn in ways and at the pace that is natural and preferred by them as individuals since they are different and learn differently.

### 2.6.2 Kolb's four stages and the learning styles

Although Kolb (in Kramer 2002:10) agrees to the idea of each learner having a preference of a learning style he however believes that each learner uses all learning styles in some way at some time in association with the four stages namely the concrete experience, reflective observation, abstract conceptualization and active experimentation stages as illustrated in Figure 2.2.

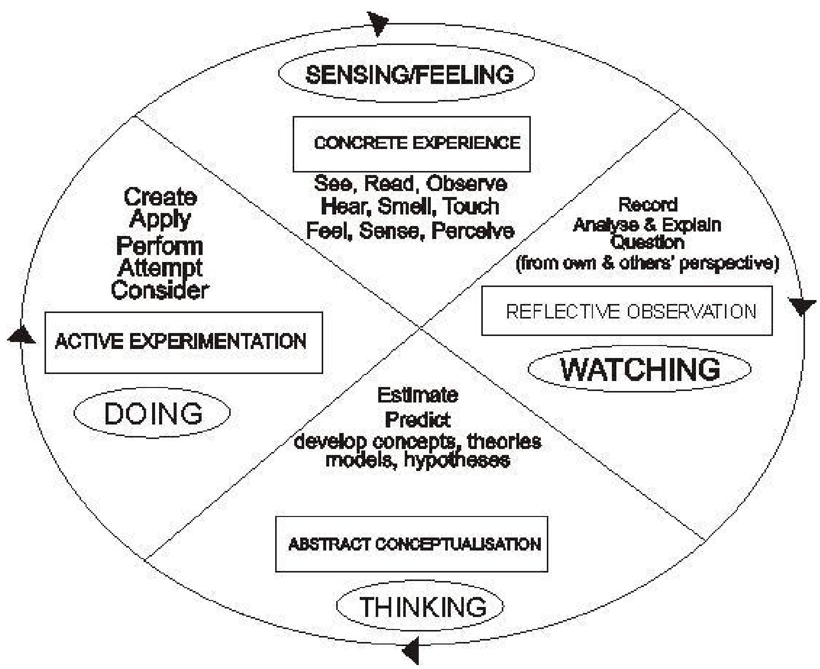


**Fig 2.2: Kolb's model of Experiential Learning: Adapted from Kramer (2002:11)**

Kolb's model clearly indicates that for learning to take place, learners need to complete the whole cycle which involves four stages and sensory channel or modalities such as the ( Kramer 2002:12):

- *Concrete experience:* where learners rely on experience and intuition. Experience involves interaction of senses with things or objects and therefore the learning style involves seeing, hearing, smelling, feeling and tasting.
- *Reflective observation:* where learners try to make sense, understand the experience, think about and analyse the experience. They learn through perception, observation and demonstrations.
- *Abstract conceptualization:* where learners think about the experience and try to create mental models, theories and ideas that explain it. They learn by analyzing logically and giving conclusion.
- *Active experimentation:* This last stage involves testing the learners' understanding by doing something to prove. At this stage learners experiment and they learn by trying things out or putting theory into practice.

It is possible to suggest that if science educators use Kolb's model by integrating the four stages with the sensory channels/learning modalities in planning instructions and in the teaching process, learners may complete the learning cycle and develop skills that require them to hypothesise, observe, analyse, reflect and predict during an investigative experiment rather than replicating an activity shown by the educator or given in the book.

## 2.7 Integrate learning theories to develop science process skills.

The ultimate goal of integrating some characteristics of each learning theory in a balanced way is very crucial for the development of science process skills in learners. It is believed that science process skills are the focus of all science learning and assessment activities in classrooms (South Africa 2003:10). It is through these skills that learners develop thinking skills that are valued as outcomes of science education and develop the understanding and ability to identify and use relevant scientific evidence in solving problems and making decisions (Harlen 2000 :31, South Africa 2003 :13). Science teaching and learning should therefore aim to develop fundamental science process skills in learners since they form the foundation for scientific methods (Charlesworth & Lind 2003:472).

The crucial science process skills emphasized by the South African curriculum among others include observation, raising questions about the situation, hypothesising, planning science investigations, conducting investigations, comparing, sorting and classifying, measuring, recording information, analyzing data, interpreting information, predicting, and communicating science information (South Africa 2003 :2 & 10).

Science learners often build science concepts related to the properties of objects and various materials by engaging in a variety of experiences requiring them to observe the properties of the objects, compare objects for their observable similarities and differences and grouping them based on observed similarities (Charlesworth & Lind 2003 :479). In other words, scientific knowledge in a classroom or laboratory results from the learner's use of senses to a large number of independent observations before generalization is justified.

It is therefore very important for each science learner to be given opportunities to observe in a practical situation because observation is the basis of all means of collecting data in science (Harlen 2000:34). Educators should therefore ensure that observations are repeated under a wide variety of conditions so that learners are exposed to experience before they are given a universal law or general statement. Once exposed to experience it is then possible for learners to get from singular statements that result from observation to the universal statements that make up scientific knowledge.

It is documented that scientific knowledge obtained through observation and experimentation is usually reliable since it is objectively proven knowledge and derived from facts of experience acquired (South Africa 2003:10, Hung 1997:266). Even great experiments of pioneering scientists such as Galileo and Newton regarded experience as the source of scientific knowledge rather than intuition (Hung 1997:77). Furthermore, during scientific revolution Francis Bacon and his contemporaries vowed that if nature is to be understood, it must be consulted through the faculties of sight, hearing, smell, taste and touch (empiricism) and not through the writings of Aristotle and his contemporaries who trusted the mind with its power of reasoning and insight as the only source of knowledge (rationalism) (Hung 1997: 19, 94 & 261).

Hung (1997:266) adds a further dimension when he clearly states that for one to understand the world, the mind alone is powerless since it can only provide analytical knowledge and does not provide synthetic knowledge (about the real world) that requires the faculties of the senses. Therefore it may be argued that educators should develop in learners both analytical and synthetic knowledge by providing them with opportunities to do free exploration using the science process skills so that they have clear and deep understanding as well as have true knowledge of concepts and processes rather than memorizing facts alone.

However learners should be allowed to apply these science process skills in sequential order of increasing sophistication although they use all the skills alongside one another at various times during discovery (Harlen 2000:37, South Africa 2003:20). This implies that each process skill includes the previous skill. For example, a learner cannot make comparison without making an observation and cannot also organise objects without making comparisons.

## 2.8 Summary

The factors that affect teaching and learning of science were discussed in relation to learning theories. The chapter also looked at the major roles of learning theories in teaching and learning of science, how the learning theories can be applied and be integrated in the teaching and learning of science.

Therefore the above literature review substantiates the assumption that learning theories play a major role in the science curriculum that is selected for learners and the way learners are taught (Morrison 2009:113). In other words, the experiences that make up the science curriculum are at the core of the learning process, and experiences provided to learners by educators should be based on how they learn.

The composite picture that emerges from various learning theories as discussed in this chapter indicates that once educators know how their learners learn, it makes easier for them to plan, teach with guidance and provide support to enhance learning, and evaluate learning on the basis of learning theories (Berk 2006:251, Morrison 2009:114)

The next chapter describes the literature review on previous research studies that were done elsewhere and in South Africa on factors that causes high failure rates in sciences at high school level.

# CHAPTER 3: LITERATURE REVIEW: PREVIOUS RESEARCH

## 3.1 Introduction

There is an on-going battle worldwide by several researchers in an attempt to uncover the root causes of high rates of failure in secondary level science classes. This is evident in some past and most recent research studies that lack of both necessary inputs (such as material resources and qualified science educators) and efficient supportive systems and environments within the school are major contributory factors of under-performances in science (Karunaratne 1998:2-14, Shumba 1999:55 -72, Howe 2003:1-20, Van Loggerenberg-Hattingh 2003:52-57, Fonseca & Conboy 2006:82-92, Ruby 2006:1006-1027, Vos, Devesse & Rassul Pinto 2007:51-66).

Research in both developed and under-developed countries, indicates similarities of a wide spectrum in factors that cause poor academic performance of learners at high school level across all subjects (Lemmer 2000:81, Schneider et al 2002:411-412, Phurutse 2005:1-20, Taylor 2009:12-15). Despite important value differences, these writers agree on the following as the key causes of poor performances in any subject of which science is not an exception:

- Highest number of learners per class,
- Lack of facilities and material resources,
- Highest educator and administrator turnover,
- Highest absentee rates among educators and learners,
- Heavy teaching loads,

- Shortage of qualified-subject specialists (experts),
- Poor teaching methods,
- Inadequate communication ability of learners and educators in the language of instruction,
- Unmotivated educators/learners, and,
- Tendency to place the greatest demand on educators' time and energies in terms of discipline, lesson planning, unproductive paper work and time management.

In similar but separate studies in an attempt to unravel factors affecting mathematics and science achievement, other researchers have expressed and emphasized their findings in an interesting and quite different way (Lemmer 2000: 9, Howe 2003:4, Kanyongo et al 2007:38). They suggest that learners' academic achievement should be viewed in the context of an input-process-output (outcome) framework, particularly in terms of interaction between the input and process factors.

The apparent convergence of their findings suggests that there is a strong relationship between the input and the process factors within the school as a system which ultimately determine the outputs (outcomes) or learners' achievement.

### 3.1.1 An Input- Process- (Output) Outcome Framework

In the light of this framework, Howe (2003: 4-5) proposes that factors that are linked to day- to day activities in which the educators carry out their duties affect the level of academic performance of learners and include aspects of internal organization structure ( school's internal structure) such as:

- Clearly articulated goals, the human management style, information with regard to norms and standards and support to both educators and learners,
- Delegation of authority, supervision and communication by heads of departments, autonomy in undertaking tasks, availability of resources, qualification of educators, subject- specific expertise, system of feedback and development of educator knowledge and skills, as well as motivation of both educators and learners, and,
- Interaction between educators and learners within the classrooms (relating to what is taught and how it is taught) (Howe 2003:4).

While large scale research studies on learner characteristics as important components of education that affect achievement in science are sparse, both Howe (2003: 5) and Kanyongo et al (2007:38)'s framework made a major contribution by indicating that the learner's aptitude and ability, perseverance and commitment as well as school readiness are associated with achievement results. Fig 3.1 depicts a complex and comprehensive link between the input and the process factors as well as their interactions within the school as an organisation that affect the learner's academic achievement in science (Howe 2003:4).

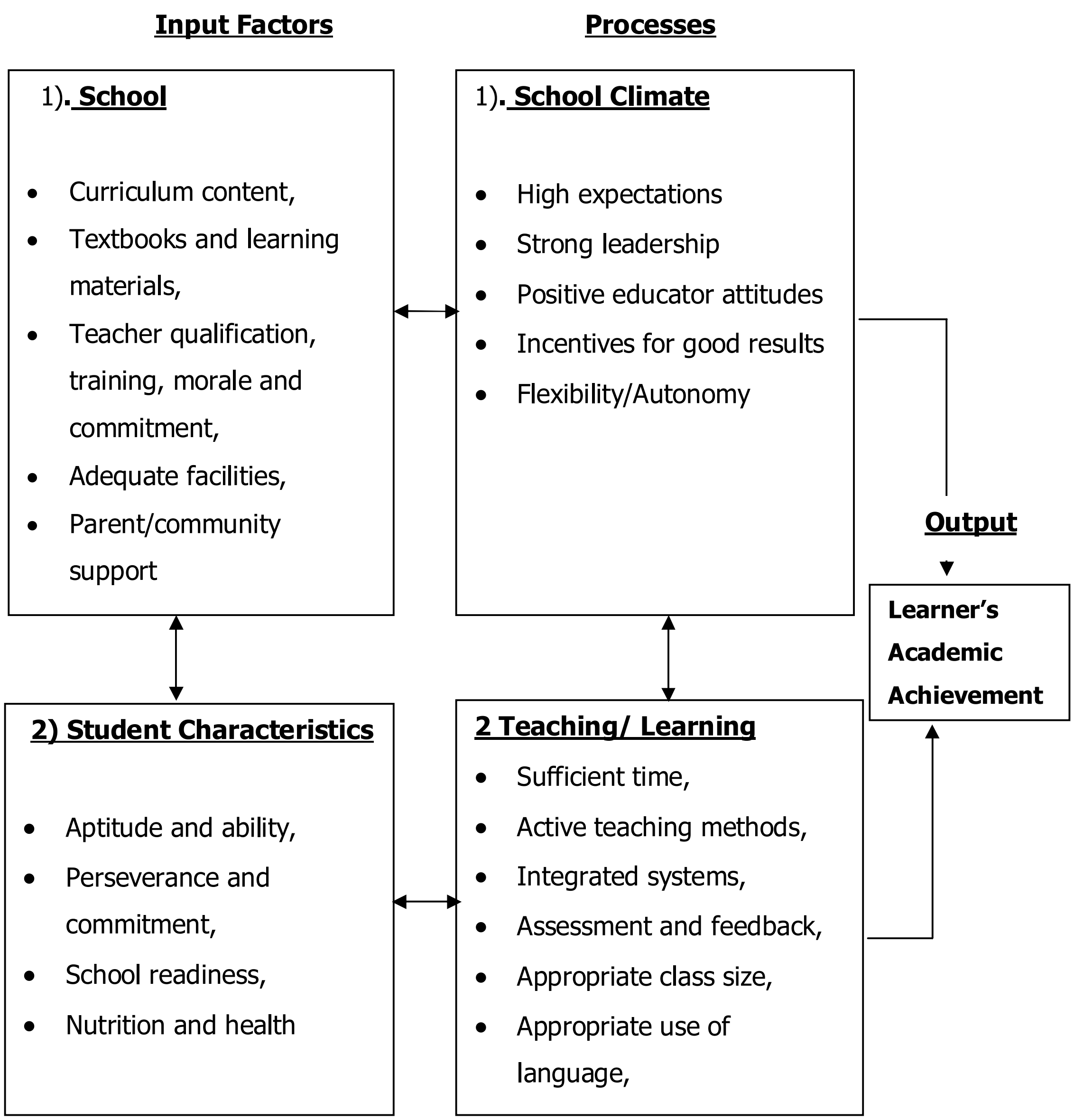


**Figure 3.1: An Input-Process-Outcome framework adapted from Howe (2003: 4-5).**

There are a few definite conclusions that can be drawn from the above framework on the aspect of learner's achievement in science at high school level. For instance, it may be deduced that both the input and process factors have sub-factors that are complementary, intimately interrelated and that also act as important determinants of learner's success in science.

Furthermore, the framework shows that input factors fall under two categories which affect each other, namely:

- *School factors* such as science curriculum content, adequate science facilities (e.g. laboratories, equipment, textbooks and other learning materials), science educator's qualifications, science educator's training, subject-specific expertise, educator morale, educator commitment and parental involvement, and,
- *Science learner's characteristics* that include learner's aptitude, ability, perseverance/commitment, school readiness as well as the learner's nutrition and health.

On the other hand, the process factors can be viewed in terms of:

- *The school climate factors* such as high expectations, strong leadership(management style), positive educator attitudes, incentives for good results, flexibility/autonomy, and,
- *Teaching and learning activities*, which involve sufficient teaching time, active teaching methods, integrated systems, assessment and feedback, appropriate class size and appropriate use of language.

It may be expected due to the dynamics of this framework, that improving interactions among all these factors (input and process) results in positive and fruitful outcomes such as improved participation in science class, learners' attitudes towards science, aspirations for the future and eventually high pass rates in science (Howe 2003:4, Lemmer 2000:90-91). Due to these reasons, the framework was viewed as an ideal model and was therefore used as the basis on which this study was based and guided the whole study on an exploration of the causes of high failure rates in science at matriculation level in public high schools of Alexandra Township.

### 3.2 Research Studies Done Elsewhere

In United States, Ruby (2006:1005-1027) through the Centre for Social Organization of Schools at Johns Hopkins University, began to investigate the causes of low levels of science proficiency in Philadelphia that had posed significant challenges both to individual learner's success in high school science and to national and local efforts to reform science education. His major aim was to establish a global theory on improving science achievement at high-poverty urban middle schools.

He found evidence to suggest that low levels of science proficiency was associated with challenges faced by these schools in terms of variation in science curriculum, student background, lack of materials, unprepared science educators and unqualified science educators who lacked background to teach middle school science and was coupled by lack of in-service professional development.

Similar studies have been made in Portugal (Fonseca & Conboy 2006:82-92), in Australia (Barton 2007:323-324) and in Maine (Hickey 2008:1-2).

Although Ruby's (2006:1007) study departed significantly from those of others in the sense that it was based on samples of science learners in high-middle grades other than the high school final grades, together they share and strongly emphasize the fact that most schools face critical shortage of qualified science educators.

Educator qualifications together with content knowledge in mathematics and science has become a popular topic in countries such as the United States, Australia, New Zealand, Canada and others due to acute shortage of educators in these fields that has caused retarding success in science (Henry 2001:1-3, Kanyongo et al 2007:39, Einhorn 2008:2). In this regard further evidence by Kanyongo et al (2007:39) shows that some researchers have attempted to take a step further to examine the impact of educators' qualification and content in mathematics and science on learner's achievement using a sub-sample of NELS-88 in United States. They found that educators with MA and BA in mathematics and science had statistical significant ($t = 3.6$, $p<0.05$) positive impact on learners' achievement and could use appropriate laboratory procedures in teaching and learning relative to educators without advanced degrees.

### 3.2.1 Laboratory Work

Early research study by Saunders and Shepardson (1987:41-49) provides some valuable insights that suggest that laboratory activities play an important role in two educational outcomes such as science achievement and cognitive development. They concluded that appropriate interaction of learners with materials and events in a laboratory that involve both hands-on and minds-on develops higher order skills like problem solving skills, creative and critical thinking skills, collaboration skills and communication skills. However laboratory work is believed to be one of the most challenging aspect of science teaching when compared to some other subjects because it requires careful planning and considerable expertise on the part of the science educator (Archer 2006 :X1, 38). Therefore, Duit et al (2007:60) advise science educators that planning of laboratory activities should provide learners with opportunities of coming face to face with the real world so that there is promotion of complex cognitive processes that take place during the learners' engagement with real apparatus. They further argued that laboratory work should be designed to:

- Increase motivation among learners,
- Improve learners participation,
- Enable learners to link theory to practice such that they can realize the magnitude of deviation which exists between the abstraction and the physical reality, and
- Improve science achievements.

Perhaps the most recent and renowned study in science education on laboratory works remains in a research project and development work carried out in five European countries in the context of the European Project (Psillos & Niedderer 2006:1-29). A summary of this research project which lasted for 28 months revealed that learners perform poorly in science because:

- Of poor laboratory practices which are ineffective,
- Most laboratory activities are poorly designed and planned with regard to the levels of understanding of the learners such that learners end up manipulating equipment but not manipulating ideas,

- Much time is usually wasted in laboratory when learners engage in data gathering without knowing why they are doing it, and
- Learners are not given adequate opportunities for processing and analyzing data (Psillos & Niedderer 2006: 2-3).

Despite these important value findings, it may however be argued that the study only generalized results of poor performance of learners in laboratory works without considering the primary challenges faced by science educators in these laboratories when teaching learners from diverse backgrounds in terms of race, culture, language and socioeconomic status (Lemmer, Meier & Van 2006:51, Norman et al 2001:1101-1114).

**3.2.2 Racial, Linguistic and Cultural Diversity.**

Areas of study that have attracted rather much attention in developed countries such as United States, United Kingdom, Canada and Australia in an attempt to unravel the causes of learners' poor performance in science focused mainly on learner diversity in terms of racial, language, cultural backgrounds and socioeconomic status (Marshall 2002:3, Lemmer et al 2006:21, Norman et al 2001:1102).

For example, studies in United States suggest that the minority racial and cultural groups of Black and Hispanic science students displayed poor academic performance as compared to White American students of the dominant race and culture (Lee & Luykx 2006:11-13).

Further, evidence from separate studies on "Achievement of Science Students by Gender" also revealed that female African-American and female Hispanic students scored very low in academic achievements at each grade level as compared to female White and Asian Americans(Lee and Luykx 2006:16). Similar results were obtained in an attempt to find out achievement gap that existed between African American and White students in science (Norman et al 2001: 1101-1114).

These recent studies together with earlier ones that were documented in the long history of research among the minority racial and cultural groups of Maori in New Zealand, Aboriginal children in Australia, Afro-Caribbean descent in Britain and Inuit in Canada (Hodson 1993:686) established common factors that cause poor performance in science. Together they emphasize that:

- Many science educators are challenged both professionally and personally by the populations of learners from diverse racial and cultural backgrounds they encounter in their science classes (Marshall 2002:3, Lemmer et al 2006:21). The reason could be because too often, the educators' knowledge of science and/or learner diversity is insufficient to guide learners from diverse backgrounds to meaningful science learning which results in poor performance in science by learners (Trowbridge et al 2004:292),
- Science learners who come from different racial or cultural backgrounds to those of their science educators and/ or dominant race or culture, experience racial or cultural alienation and discontinuity which lead to poor performance in science (Marshall 2002:297, Lemmer et al 2006:19).

- Cultural diversity is not adequately represented in science curriculum, textbooks, most materials, teaching methods, experiences, needs, interests and aspirations such that the quality of instruction favours the dominant cultural group while it is detrimental to the minority group.(Trowbridge et al 2004:258-259,292).

Related to these, are two separate survey studies. For example, an earlier one which was done in England that focused on science learners from a broad range of language communities, particularly immigrants (Strevens 1976:55-68). Another recent one in the United States that concentrated on Spanish speakers when the vehicle of instruction was not their mother tongue (Lee & Luykx 2006: 35).

Both studies showed that learners who were taught in English for whom it was a foreign language performed poorly in science as compared to those who were taught in English which was their mother tongue. It was further established that if English was a foreign language to the science educator, the educator also often found that new techniques made demands upon his spoken English which he could not meet. Together, these studies may suggest that:

- Learners' limited proficiency in a second language constrains their science achievement when instruction and assessment are exclusively or predominantly in a second language. This is because learners who come to a science lesson taught in a second language usually bring their attitudes, cognitive styles, social and linguistic skills that have been developed in their first language (Lemmer et al 2006: 51).

- A wide range of possible communication problems between the educator and the learner emerge when science is taught in English to learners whom it is a foreign language which may lead to poor performance (Marshall 2002:3-4). For instance, non-English speaking learners need to develop English language and literacy skills in the context of content area instruction while content area should provide a meaningful context for English language and literacy development.

When these factors are taken together, it may be possible to suggest that cultural norms governing classroom discourse are large, implicit and tacit, and thus are not easily accessible to learners who have not learned those (Lemmer et al 2006:52). It may be further suggested that science educators need to be aware of a variety of cultural experiences in order to understand how different learners may approach science learning, use cultural artifacts, examples, analogies and community resources that are familiar to learners in order to make science relevant and eligible to them (Trowbridge et al 2004:278, Norman et al 2001:1110).

In similar studies in the three sub-Saharan African countries (Botswana, Namibia and Lesotho), Kanyongo et al (2007:37-46) attempted to find factors affecting mathematics among 6$^{th}$ graders while in the fourth sub-Saharan country (Mozambique), Vos et al (2007:51-56) focused on the designing of learner-centered instruction in mathematics lessons. Although the findings in these sub-Saharan countries agreed with other research studies described above on cultural background, language of instruction and lack of qualification by educators as the main contributory factors to learner's poor performance they differ in the sense that they mainly focused on improvement of teaching and learning of mathematics other than science.

Nevertheless, their additional findings indicated problems such as large classes, absenteeism by both educators and learners and acute shortage of resources of which are also common to South African schools as shown in the next section.

### 3.3 South Africa

Of many researchers who looked at factors associated with poor performance of learners in science in South Africa some agreed on at least the following points: inadequate communication ability of learners and educators in language of instruction, large classes, lack of qualified science educators, poor teaching methods, inadequate educator knowledge, poor time management, lack of material resources( such as textbooks, scientific calculators and laboratory equipment), disruption in class, content coverage and lack of professional leadership( Phurutse 2005:5-18, Mji & Makgato 2006:253-264, Taylor 2009:12-13, Govender 2009:2 & 3, Howe 2003:1-13).

### 3.3.1 Educator Qualifications and Content Knowledge of Science

There is rather extensive literature in South Africa that has attached poor performance of learners in science to serious shortage of properly qualified and competent science educators( Cameron 2009:16, Howe 2003:1-2, Dilotsothle et al 2001:305, Mji & Makgato 2006:254, Muwanga-Zake 2008:5, Makgato 2007:91 ).

Further literature review on similar issues reveal that irrespective of significant investments in science educator development by the Department of Education through offering in-service workshops, lack of content structure and content structure for instruction remains a serious challenge in this field ( Legotlo, Maaga & Sebego 2002: 113, Aldous 2004:65). Consequently, this has:

- Caused fewer qualified science educators who have been hired from other countries (Chibaya:2007:2-3) to be overloaded and hence affect their quality of science teaching (Dilotsothle et al 2001:305), and has also
- Resulted in cognitive, instructional and affective problems (Vos et al 2007:51) due to recruitment of locally unqualified and poorly qualified science educators who lack both subject knowledge and teaching methods as a result of the apartheid legacy( Madibeng 2006:1).

In light of the above, it is high time for recognition to be given to a close bond that exists between the educator's knowledge of both the content and the teaching methods. In this regard, Trowbridge et al (2004: 26) state that having the subject content only without methods does not make one a better science educator since the two seem to have relationship of married partners who are inseparable.

This implies that the role and development of the science educator's knowledge of the subject in relation to the teaching methods forms the base of science teaching and learning, and is very essential for instructional theory (Trowbridge et al 2004:27-32). It is further argued that both are intimately interrelated such that the science educator should be in a position to transform the content structure of science into the content structure for instruction for positive learning outcomes (Trowbridge et al 2004:25-26, Howe 2003:6-8).

Duit et al (2007:601) share the same opinion when they say that the science educator should have knowledge to:

- Simplify the science concepts in order to make them accessible for learners,
- Enrich concepts by putting them into contexts that make sense to learners.

If this is expanded further, this may imply that science educator's knowledge can be viewed from three different but interdependent perspectives as suggested by Trowbridge et al (2004:25), namely:

- *The content knowledge of the subject* which include both substantive and syntactic knowledge structures,
- *The pedagogical content knowledge* which describes the depth and breadth of knowledge the science educator has about teaching science as a subject,
- *The curriculum knowledge* which includes the full range of materials with which science educators should be familiar such as textbooks, work

schedules, year planner, kinds of laboratory equipment and educational software for the particular levels they are teaching.

However data gathered from studies in South African public high schools, though it does not provide the actual figures, generally indicates that very few science educators are dominant in both knowledge content and pedagogical knowledge (Dilotsothle et al 2001:305, Muwanga-Zake 2008:4-7, Makgato 2007:90-91) while most are deficient in curriculum knowledge and experiencing ambiguity in its interpretation since it is ever changing (Aldous 2004:65, Muwanga-Zake 2008:7-8).

Taylor's (2009:13) study in one of the rural schools represents the best South African attempt to find out the content and pedagogical knowledge of educators. He administered a short language test to 23 educators. The results of the test showed that 12 of the 23 educators scored less than 50% with the lowest score of 21.7%, while one educator scored higher than 75%. The results were replicated in schools across the country in language, mathematics and science. Taylor (2009:14) concluded by saying "educators cannot teach what they do not understand themselves." The research results together with his concluding remarks shows that most South African educators lack both content and pedagogical knowledge.

Although it may be presumed that most educators including science educators do not have the knowledge which the curricular expect them to teach their children due to the post 1994's ever changing curriculum (for example C2005, RNCS and NCS), on the other hand it is possible to persuasively oppose by saying that good subject knowledge is linked together with curriculum knowledge of the subject, desirable teaching skills, educator qualities, classroom management skills, relationship with learners, dedication, accessibility and hard work (Mji & Makgato 2006: 262, Kanyongo et al 2007:39). Furthermore, the curriculum change was not only for science but also involved other subjects in which learners are currently performing far much better.

Grayson (2010:10) discusses the issue of knowledge and skills particularly in science and emphasizes the fact that many South African science educators have little content knowledge or knowledge of how to teach science. She suggests that science educators should take responsibility to increase their own knowledge of the new topics in the ever changing curriculum so that they do no omit topics which they do not understand and choose to teach only those they know.

In contrast, the Basic Education director-general, Soobrayan views the quality of teaching (pedagogies) rather than knowledge content as substandard in South Africa (Kgosana 2010:1). He strongly feels that the quality of teaching is the key to the education system in terms of learners' performance in any subject and hence needs to be improved. In this regard, a number of studies had since linked low pass rates in science to educators who still use outdated teaching methods that stick to the conventional chalk and talk teaching routine (Mji & Makgato 2006:264, Madibeng 2006:1, Muwanga-Zake 2008:4-6), instead of the modern constructivist approach which incorporates knowledge of common misconceptions and strategies for addressing them (Schneider et al 2002:411).

Although it is argued that the new science curriculum provides both the science educator and the science learner with vast opportunities to link both hands-on and minds-on, and in addition its applicability to the learners' lives (Gopal & Stears 2007:15-16, Aldous 2004:73-74), an emerging body of literature(Taylor 2006:3, Van Loggerenberg-Hattingh 2003:52, Muwanga-Zake 2008:3, ) has shown that science teaching and learning in most public schools of South Africa is characterized by educator-centered instruction associated to the drilling of scientific concepts and chorus- recitation that leads to memorization of scientific definitions, formulas as well as immediate solutions of scientific exercises without logical sequence or clear relationship between scientific concepts. This as a result, encourages most science learners to rehearse scientific laws, rules and formulas without attaching meaning to them and understanding them conceptually, leading to short-term retention, low motivation and poor performance at grade 12 (Vos et al 2007:52).

Again, it is very important to once more revisit some of Taylor's (2009:14) words, "a teacher cannot be a teacher if she does not know her subject, however much OBE jargon she can speak……." In other words, content knowledge, curriculum knowledge and pedagogical knowledge are all important in influencing learners' performance (Kanyongo et al 2007:44). Therefore, a qualified science educator should have a balance between knowledge content of science and content-specific pedagogical issues in his thinking so that instructional planning includes both content issues and issues of how learners may learn the content within the allocated time (Trowbridge et al 2004:25-27, Ruby 2006:1007).

### 3.3.2 Language of Instruction in Science.

South Africa is a multilingual country with 11 official languages. The science classes are of linguistically diverse learner population that differs from English, which remains an official language of instruction in science in most public township and rural high schools, despite the fact that less South African population can speak it.

In her study to determine the factors that influence mathematics and science performance of South African learners in order to ascertain the effect of learners' language and communication skills on achievement in these subjects, Howe (2003:8) discovered that native English speakers performed best (25 points out of 40) in mathematics and science of all language groups while the Afrikaans speaking attained the next highest score (21 points out of 40). Scores were very low and poor in learners whose main languages were African languages. More evidence from these results showed that the learner's proficiency in English, the language the learner spoke at home and the language of learning in the classroom have direct effect on learner's performance in mathematics and science (Howe 2003:9).

Further literature study reveal that South African learners whose main language is an African language often have different levels of competence in English which does not match the first language of the majority black learners (Howe

2003:7-8, Mji & Makgato 2006:261). Such dissimilarities in terms of language often complicate the experience of both science educators and learners in the classrooms. This, as a result, is believed to have particular implications for the teaching and learning process (Marshall 2002:7).

It is further established that science educators who teach such learners frequently perceive them as having no prior knowledge, no language and suffering from impoverished thinking skills because of failure to address the needs of second language (English) to learners(Howe 2003:9-11). Consequently, such learners are usually delayed in their access to scientific knowledge and further hindered from full participation in class which in turn contributes to a sense of social alienation (Lemmer et al 2006:51).

Science educators in South Africa should therefore take into cognizance a number of issues which among others include their teaching styles and techniques, interpersonal interactions in order to enhance the effectiveness of their teaching in such diverse linguistic environments so that they motivate their learners towards acquiring necessary scientific skills, scientific knowledge, values and attitudes and provide high quality of science education for all learners (Marshall 2002:21, Lemmer et al 2006:1).

Additionally, it is acknowledged that learners are most familiar and able to demonstrate higher order thinking in science such as defining, generalizing, hypothesizing, or abstraction in their own home language or in the language in which they first learn to speak, read and write (Lemmer et al 2006:17, Pillay 2004:7). However, literature on this indicates that most science learners in

South African township and rural schools lack cognitive academic language proficiency required to execute similar higher order cognitive operations through a second language such as English ( Pillay 2004:7, Mothata & Lemmer 2002:109-110, Gopal & Stears 2007:16-17). This is compounded by the fact that they are faced with triple challenges during a single science lesson ( Mothata & Lemmer 2002:107, Howe 2003:6-8) that involves:

- Mastering of the science academic content,
- Mastering of mathematical concepts used in science, and
- Mastering of English, a medium of instruction which they are not proficient in, other than their mother tongue.

Precisely, science learners are placed in a difficult situation of treating three different subjects (science, mathematics and English) in one lesson. In light of this, science educators are advised to create educational environments that allow learners to develop and maintain both their first and second language that is used as medium of instruction in the most effective and beneficial ways possible (Lemmer et al 2006 :52). In this regard, it is suggested that science should be taught in the language which the learner understands most or in the language which is most proficiently used at home (Motshekga 2006: 4). She believes that mother tongue is a useful strategy for increasing learners' access to quality education in the teaching and learning of science.

However, this will make it difficult to explain certain scientific concepts such as power, energy, force and others since one word is used to refer to these terms in most African languages.

### 3.3.3 Large Classes

Although literature fails to stipulate the optimal class size, it is however believed that the quality of the science educator's teaching, his interaction with learners, the learning process, satisfaction and active learners' participation decline with an increase in the size of the class (Lemmer 2000:83, Phurutse 2005:5). In this regard, Lemmer (2000:83-84) pursues his argument further by saying that achievements in smaller science classes of less than 15 learners exceed achievement in both average science classes of about 25 and large classes of more than 30 learners while achievement of 25 learners is only marginally better than the achievement of learners in bigger science classes.

Spelling out difficulties faced by educators, the Basic Education Minister indicated that teaching large classes of 50 or more learners in public schools is one of the many long-standing concerns facing the education system in South Africa (Cameron 2009:17).

This concern is supported by different studies carried out across the country that showed that large classes are common in South African schools and negatively affect teaching and learning of science ( Howe 2003:3, Phurutse 2005:5, Mji & Makgato 2006:254, South Africa 2009:8-9, Legotlo et al 2002:113). Subsequently, these studies also revealed that science educators, who teach smaller classes, in particular, experience more positive attitudes to learners and their work and consequently produce better matriculation results in comparison to those who teach larger science classes, where the majority of characteristics and conditions (such as lack of discipline, disruptions and other problems) present themselves as interrelated and collective constraints that impede meaningful teaching and learning.

Recent statistical analysis in some parts of the country has shown that the learner to educator ratio has been decreased to an average class size of 39:1(South Africa 2009: 9). This is as a result of increasing the number of educators at schools as well as building and opening new schools and additional classrooms in some parts of the country. However, earlier research study in Western Cape indicated that science classes of similar nature were characterized by insufficient individual interactions and rapport, lack of motivation, lack of individual attention by educator during the science lesson and inability to ensure adequate provision of learning experiences such as handling of apparatus, observation, recording of results by each learner (Gopal & Steers 2007: 16).

In contrast to this, Govender (2009:3) reported a school in Limpopo province that had an average of 54 learners in its science classes that produced the best science results. The school scored 75% and was the highest rating among the top 100 schools.

Therefore in light of this, large science class may arguably not be regarded as a contributory factor to high failure rates in science, but instead, as indicated by Phurutse (2005:15) "it influences what the educator does, his or her manner with the learners, and what the learners themselves do or are allowed to do." However, it may further be argued that a well trained and qualified science educator with classroom management skills may have knowledge to handle such large classes.

### 3.3.4 Science Achievement Gap as a Function of Time Management

Studies have indicated that time in terms of punctuality, effective use of time during the lesson and additional teaching time, among others, is a highly valued commodity in academic achievement of learners (Lemmer 2000:13, Taylor 2009 :12, Grayson 2010 :10, Makgato 2007:89).

A national survey of schools in 2003, as described by Taylor (2009:12-13) revealed high levels of educator and learner absenteeism and late coming as a widespread problem in South African public schools. Results of this survey showed a high statistical correlation with poor learner performance on tests which compared to scores across a number of SADC countries.

Similar surveys across the country reported that many South African educators spend less than half their time teaching (Taylor 2009:12). It was found that instead of focusing on science learners' usable knowledge and skills during the lesson as stipulated in OBE, educators spend much time completing endless paperwork which do not serve the purpose for the learning process other than the bureaucratic compliance such as formalistic planning documents, extensive and frequent assessment reports and forms required by the new science curriculum (Taylor 2009:13, Grayson 2010:10).

Although OBE has a creditable approach in the sense that it focuses on what the science learners are able to do than what science educators are able to teach (Aldous 2004:65), much of the problems and criticism lies in the fact that the new curriculum leaves educators overloaded with administrative paper work and very little time for the actual teaching to cover the content in the curriculum (Grayson 2010:10). This is compounded in situations where both educators and learners are not punctual for the lesson, and worst when the educators lack time management skills during the lesson (Lemmer 2000:13-14).

Muwanga-Zake (2008:5-6) has shown that most science educators in South Africa are of poor quality such that they cannot plan for a science practical accordingly. He indicated that most of the science practicals do not have clear objectives and as a result, learners waste time verifying established laws and principles or on the discovery of objectively knowable facts.

In this regard, research has shown that if the allocated time for a single science lesson is forty minutes, the engaged time or time a learner spends on a science task is only five minutes or even less of the forty minutes (Lemmer 2000:13). This is because most of the time is lost due to lack of punctuality, announcements, filling in of attendance reports and new curriculum paper work, explaining directions about a scientific task everybody has to do and how the task should be done( Aldous 2004:71-73, Muwanga-Zake 2008:5).

All these activities are not teaching the learner anything about science nor engaging the learner in the actual task. If learners do not understand the instructions, the science educator has to take more time clearing up the confusion and this means the engaged time for a given learner will be far less than 10% of the allocated time (Lemmer 2000:12-13). Therefore time management is an important aspect in teaching and learning of sciences.

### 3.3.5 Resources and Science Achievement

Research evidence in North West Province by Legotlo et al (2002:115) has shown that lack of resources is a common problem in most South African public schools. Similar findings have been documented elsewhere in the country (Mji & Makgato 2006:254, Howe 2003:2).

These studies together with others have revealed that South African public schools have a serious shortage of physical facilities such as classrooms, laboratories, libraries, chairs, chalk boards, science equipment, calculators, teaching and learning aids such as posters, charts, audiotapes and computers, and textbooks. A learners- textbook ratio of 10 to 1 was recorded (one textbook for ten learners) in most schools (Legotlo et al 2002:115).

The findings of these studies taken together established a compelling relationship between resource availability and achievement in science and have indicated that science achievement gap in South African schools is a function of resource. However, these studies have also established a growing consensus that laboratories and science equipments have a greater impact on the learners' achievement in science than other resources in a school.

Despite important value similarities mentioned above, Muwanga-Zake's (2008:3) findings in the Eastern Cape, however, disagree with other researchers when it comes to the inadequacy of science resources in schools. He proposed that some educators make a false claim that they do not teach science practically due to shortage of apparatus. He discovered that the inability to teach science practically was because some educators could not operate certain apparatus/equipment which was already in the schools and as a result, they avoided them and left them in the storeroom to gather dust. He even found some unused chemicals that had expired in the storeroom.

Drawing on international research done elsewhere, Bubenzer (2008:3) revealed that resource increases alone, such as more educators, textbooks or other material resources is not the answer of improving results in science, but rather effective and rigorous management by principals and heads of subjects was imperative.

### 3.3.6 Roles and Functions of Professional Leadership in Science Education.

The school's leadership includes the principal and the subject heads, of which the head of science department is not an exception. Early research by Cawood and Gibbon (1981:6) showed that the school's leadership influences the destiny of both educators and learners. More recent and significant review on this by Grayson (2010:10) showed that the school leadership is responsible for instructional practices and supervision processes, such that its organization stands or falls on the strength of its leaders. The strong relationship between these two similar views implies that dynamic and effective leadership in the

school makes a major impact on the caliber of education, promotes effective teaching and learning which in turn influence the performance of learners.
Legotlo et al's (2002:116-117) study in a rural province of South Africa provides a composite picture of a number of features that causes high failure rates at matriculation level which are associated with poor management skills and leadership. They recorded higher pass rates in rural schools that managed their resources effectively and created a learning environment which maximized learning by monitoring curriculum coverage, provided opportunities for in-service development of educators, supervision of educators and planning while on the other hand, they recorded poor performances by learners in schools with poor management and leadership skills. Their findings demonstrated the growing realization that the effectiveness of school leadership has a far reaching influence on the school's ability to mobilize both human and material resources and enhancement of academic performance.

Further literature review (Prince & Nelson 2007:4-5, Dilotsothle et al 2001:307-308, Trowbridge et al 2004:341-342) has shown that excellent leadership and management skills, particularly by the head of the science department are characterized by:

- Setting of goals for the department,
- Shaping a dynamic subject team characterized by a positive climate of openness and co-operation,
- Knitting science educators into a subject team which has a climate in which each individual member is able to realize his maximum potential,
- Prioritization of team-building, group work and group morale among educators,
- Initiating staff development programs, in-service training, workshops and supervision of science educators,
- Ensuring that the facilities and materials are adequate for the kind of science being taught,
- Promoting the teaching of the subject by leading and advising science educators so that they become effective educators and,
- Excelling of learners in science.

However, it is argued that most South African public high schools have principals, science subject advisors and heads of science departments who lack both knowledge of the subject and management qualifications and skills (Dilotsothle et al 2001:305,307-310, Grayson 2010:10, Legotlo et al 2002:116). Yet they are the cornerstones who have an influence on the teaching and learning of science in schools. Kramer (2002:24) shares the same feeling by saying, "The way we manage schools will have an impact on the level of success achieved by learners. Effective, well-managed and operated schools will facilitate successful learning. Poorly operated, resourced and managed schools are likely to retard successful learning."

### 3.3.7 Learner and Educator Commitment

Legotlo et al's (2002:115-116) study, supported by that of Muwanga-Zake (2008:10-11) suggest that lack of commitment by both educators and learners, is common and is at its climax in South African public high schools. Both studies further suggest that lack of commitment and low morale by science educators is due to being overworked since science requires more input than other subjects, low salaries for educators as compared to scientists in industries which lead to late coming, absenteeism and non-performance of duties and ultimately poor performance by learners. With regard to learners, Legotlo et al's (2002:115-116) findings show that lack of commitment and perseverance by learners in their studies, lack of discipline which lead to uncontrollable behaviour and deliberate ignoring of instructions from educators eventually affect the relationship between educators and learners and as a result affect their performance.

## 3.4 Summary

This chapter focused on literature review from previous research on school related factors that cause high failure rates in science at secondary school level. Various sources with reference to other countries and South Africa were consulted in order to establish school related factors that hamper teaching and learning of science. Factors that lead to learners' success in science were also identified.

However it was impossible within the scope of this chapter to include every significant research study in the field of science education that addresses all school related factors that cause high failure rates. Rather, this chapter has cited research studies which by the judgment of the researcher best illustrated an overview of key school related factors through sampling of the relevant research.

Literature review in this chapter has established that factors which cause poor performance in science are common in both developed and under-developed countries but are more acute in under-developed countries including South Africa. However these factors are exacerbated in both developed and under-developed countries by lack and ineffective integration of input and process factors within schools.

The next chapter describes the research methodology adopted for this study.

# CHAPTER 4: RESEARCH METHODOLOGY

## 4.1 Introduction

This chapter describes the research methodology that was used to establish the school related factors that cause high matriculation failure rates in public high schools of Alexandra Township. It includes details of the research design, the methods, the description of the population, the sample, the data collection tools, content of the instruments, validity and reliability of the instruments, pre -testing of data collection instruments, the pilot study, information about the data analysis procedures and ethical issues that were implemented.

## 4.2 Research Design

According to McMillan and Schumacher (2001:166) a research design describes the plan for selecting the subjects, research sites, data collection methods, data analysis methods and how the data is to be presented to answer research question(s). Its major and ultimate purpose is to provide results that are judged to be credible.

With reference to the purpose of this study, which was to investigate the school related factors that cause high matriculation failure rates in science, a quantitative research approach using an explorative and descriptive survey design was followed. This research approach necessitated data gathering from science learners and educators who directly experience the effect of the teaching and learning processes so that more effective insight into the causes of high failure rates in science at matriculation level could be unraveled. In addition, data obtained by this design approach is more trustworthy and reasonable (Gay, Mills & Airasian 2006:11).

### 4.2.1 Quantitative Design

Quantitative research is a more scientific approach to the study that collects and analyses numerical data which is concerned with the relationship of one set of facts to another (Bell 2005:13, Gay et al 2006 :9, McMillan & Schumacher 2001:165). It usually reduces measurement to numbers (Johnson & Christensen 2008:37). In other words, it describes relationship in phenomena as the degree of influence one factor has over another in terms of reciprocal influences (Borg, Gall & Gall 2005:226-227, Gay et al 2006:10). As a matter of fact, quantitative research embraces the assumption that individuals inhabit a relatively stable, uniform, and coherent world that can be measured, understood and generalized by striving to establish relationship between two or more variables (Bell 2005 :14, Gay et al 2006:9).

Hence in this study, quantitative design was selected because it necessitated a deeper and better understanding of the relationships between high failure rates in sciences at grade 12 and its causes or factors which were under investigation, without personal interactions with the subjects (Gay et al 2006:10). This implies that most of the data was gathered using paper-and-pen, non-interactive instruments (questionnaires).

### 4.2.2 Descriptive Design

Descriptive research aims at providing a clear and accurate description of individuals, phenomena or processes. It involves, according to Gay et al (2006:10), collection of data in order to describe current status or conditions by allowing the researcher to generate new knowledge of the subject through intensive examination of phenomena.

In this study a rich description of the experiences of science learners and science educators was seen as an ideal one and was provided. The data from the questionnaires were used to describe the phenomenon, through emerging patterns, to ensure the descriptive nature of this research. In addition, a dense description of both science learners and educators' world of experience in class was provided so that the data from the questionnaires could be viewed from the science learners' and educators' perspective since they are the ones involved in the teaching and learning experiences.

### 4.2.3 Survey Design

A survey involves taking general views of, scanning and examining opinions, beliefs, attitudes, values, characters, demographics, habits, desires, ideas, and other types of information(McMillan & Schumacher 2001 :304, Gay et al 2006 :161). The intention of surveys as further propounded by Bell (2005:13) and Robson (2007:41) is to describe the incidence, frequency or distribution of characteristics of an identified population. It is also believed that surveys investigate the cause and effect relationship between variables or current status by collecting data from members of a population (McMillan & Schumacher 2000: 283).

Therefore in view of the above, this study followed the survey design because it provided information that made it possible to gain insight into various causes of high failure rates in science directly from the ideas and opinions of science educators and learners themselves who directly experience the real situation.

In addition, the survey design enabled data to be gathered from a larger sample of science learners and educators in same circumstances (McMillan & Schumacher 2001:177). The choice of survey design in this study did not lie only in its versatility and generalizability to be used in almost any problem or question, but also in its ability to be used for practical purposes and its ability to describe data by comparing and relating one characteristic to another (Gay et al 2008: 421). This in turn enabled the researcher to demonstrate that certain features existed in certain categories (Bell 2005:14).

Another important reason for using the survey design in this study is that it was assumed to be efficient because data on many variables could be gathered without substantial increase in time on a sample selected from a larger population in ways that permitted generalizations to the population (McMillan & Schumacher 2001 :178).

### 4.2.4 Exploratory Design

Explorative research allows for an in-depth examination of the phenomenon which has not been studied previously (McMillan & Schumacher 2001:101).

Therefore this study followed an exploratory design in order to gain facts and generate a general picture of school related factors that perpetually cause poor performances in science at matriculation level because no such previous studies were done in Alexandra Township before.

## 4.3 Population

The target population may be described as the entire group of individuals having the characteristics that interest the researcher (McMillan & Schumacher 2001:169, Johnson & Christensen 2008:224). In other words, it is the same group of individuals which the researcher would like the results of the study to be generalized.

For this study, the target population comprised of FET science educators and learners in all public high schools of Alexandra Township. Therefore the generalizations for this study were made from the research which focused on FET science educators and learners in all five public high schools of Alexandra Township.

### 4.3.1 Sampling

Sampling refers to a process of selecting a portion of the population to represent the entire population (Johnson & Christensen 2008:222). On the other hand, a sample is the number of individuals selected from the target population for a study (McMillan & Schumacher 2001:169), preferably in such a way that they represent the larger group from which they were selected (Gay et al 2008:224). A sample should be a representative of the wider population so that it would be possible to make statistical generalizations which are unbiased (Robson 2007:98).

Due to many FET classes and their sizes, it was impractical and unnecessary to measure all elements of the target population (McMillan & Schumacher 2001:170), and as a result, a sample of two public high schools was selected.

### 4.3.2 Sample Selection

While there are several sampling methods that could have been used to select the sample of high schools, it was decided that the extreme-case sampling method could be most suitable for this study. Since the study focused on poor performance, schools with a very great degree of poor performance for the most recent year 2008 (Table 1.1) were selected.

Although Johnson and Christensen (2008:244) view extreme-case sampling as a method of selecting cases from the extremes or poles and compare them, this study followed a new and dynamic view of selecting schools that were situated at one extreme end or pole in terms of poor performance. This study therefore focused on this extreme case without necessarily comparing it with the other extreme.

The sampling criteria for the public high schools consisted of both inclusion and exclusion criteria. Inclusion criteria refer to the characteristics that the elements should have to be included in the study while the exclusion criteria refer to the characteristics that should be considered to exclude the elements from the study (Johnson & Christensen 2008:239). Consequently, the inclusion criteria in this study involved all public high schools with an average pass rate of 29% and below (not achieved) since this was considered to be the extreme poor performance, while exclusion criteria involved all public high schools with an average pass rate of 30% (elementary achievement) and above for the year 2008 (South Africa 2008:5).

This selection method was ideal because it allowed for coverage of all public high schools in Alexandra Township. As a result, school A and B (Table 1.1) were selected for this study because the average pass rate of each of these schools was below a threshold of 29%. FET science learners and science educators in both schools were requested to participate in the study.

Despite strong emphasis by Johnson and Christensen (2008:241) that sampling error would be zero if the complete population is included in an extreme case study than drawing a sample, for the purpose of this study it was essential to draw a sample of learners due to the large numbers of FET science learners involved in both schools (Table 4.1), and to save time without sacrificing accuracy (McMillan & Schumacher 2001:170).

**Table 4.1: total number of science learners per grade (2009)**

| **Grades** | **Number of Science Learners per Grade** | |
|---|---|---|
| | **School A** | **School B** |
| **10** | 145 | 129 |
| **11** | 113 | 115 |
| **12** | 120 | 74 |

A sample of 250 FET science learners (Table 4.2) and all 10 FET science educators (Table 4.3) was selected. A larger sample was used to safe guard against the sampling error, because the larger the sample the smaller the sampling error and the more representative and accurate conclusions and generalizations (Johnson & Christensen 2008:241, McMillan & Schumacher

2001:177, Robson 2007: 98). In addition, this also ensured that predictions and conclusions were reliable and valid.

Sampling bias is described as a systematic over- or under- representation of certain population characteristics that are relevant to the study (McMillan & Schumacher 2001:170, Johnson & Christensen 2008:223, Gay et al 2006:111). To minimize sampling bias in this study, proportional stratified random sampling method was used to have equal representation of science learners from both schools in terms of numbers per grade, gender and finally the correct sample size. Proportional stratified random sampling is a technique in which a population is divided into subgroups (strata) according to stratification variables such as gender, age or level of education and then a sample is randomly selected for each subgroup or strata in the same proportion in which they exist in the population(Gay et al 2006 :103-104, Johnson & Christensen 2008: 233).

The proportional stratified random sampling employed in selecting the sample of subjects involved the following processes (McMillan & Schumacher 2001:172, Johnson & Christensen 2008:231):

- Lists of all science learners were acquired before hand (on day one of visiting the schools),
- Learners were divided into subgroups (strata) on the basis of gender and separate lists of males and females were made per grade for each of the two schools,
- Names of science learners per grade were written on pieces of paper ,
- Names of boys per grade where put in a separate container with those of girls,
- In a raffle format, a boy's name per grade was randomly selected and then followed by the girl's in the same grade from the other container. This was done to offset gender bias and to enable the researcher to compare subgroup results.

To ensure that there was an equal representation of numbers of learners from each of the two schools per each grade, the ratio of 1:1 was used to select learners for grades 10 and 11. Selection of learners from both schools using such a ratio was more ideal because the numbers of learners per each of these grades in both schools were approximately more or less the same (Table 4.1).

As a result, 54 learners were selected from grade 10 of each school giving a total sample of 108, while 44 learners were also selected from grade 11 of each school to give a total sample of 88 learners (Table 4.2).

However a ratio of 2: 1 was employed to select grade 12 learners because school A had approximately twice the number of learners as compared to school B (Table 4.1). In other words, for every one learner selected from grade 12 in school B, two were also selected from the same grade in school A. This resulted in 36 learners from school A and 18 from school B with a total sample of 54 for grade12 learners from both schools (Table 4.2).

**Table 4.2**: **Category of respondents (science learners)**

| Category | Learners in sample school(N) | Sample (n) | n (%) |
|---|---|---|---|
| Grade 10 learners | 274 | 108 | 39.4 |
| Grade 11 learners | 228 | 88 | 38.9 |
| Grade 12 learners | 194 | 54 | 27.8 |
| **Total** | **696** | **250** | **35.9** |

Literature has shown that determination of a sample size should take into consideration several factors such as the type of research, research question(s), financial constraints, the importance of the results, the number of variables studied, the methods of data collection and the degree of accuracy needed (McMillan & Schumacher 2001 :177, Johnson & Christensen 2008 :24).

In quantitative studies, the emphasis is usually stressed on relying on the judgment of the researcher or his estimation to select a sample that is representative of the population and large enough to answer the research question(s) in order to obtain meaningful statistical analysis that also controls any sampling errors (McMillan & Schumacher 2001 :176, Johnson & Christensen 2008 :514). Therefore the selection of 250 science learners as a sample size in this study was mainly based on judgment of the researcher, and this sample size was adequate and large enough to answer the research questions as well as offsetting any error in terms of provision of the data for this study.

Because the population of science educators was significantly smaller, therefore all science educators in both schools were used in answering the questionnaire to ensure a meaningful statistical analysis (Table 4.3).

**Table 4.3: Category of respondents (science educators)**

| Category | Educators in sample school | Sample (n) | n (%) |
|---|---|---|---|
| FET Educators | 10 | 10 | 100 |
| **Total** | 10 | 10 | 100 |

## 4.4 Research Instruments

Research instruments are described as tools used for collecting data needed to find solutions to the problem under investigation (McMillan & Schumacher 2001:166). The main or central data-collection instrument used in this study was by means of questionnaire. According to Johnson and Christensen (2008:170) a questionnaire may be described as a self-report data-collection instrument that each research respondent completes as part of a research study.

Although there are several research instruments that could have been used for this study, the questionnaire was considered the best research tool because of the following reasons:

- It is the most widely used technique for obtaining data from subjects (McMillan & Schumacher 2001 :257) and therefore the subjects in the target population were assumed to be much familiar with questionnaires,
- It is considered to be relatively economic and therefore was assumed to be convenient for collecting data from a large sample of science learners and educators. In addition, since it is simple and requires less time, it would not take much time of science educators and learners who are already overloaded with school work,
- It is normally treated confidentially and safeguard anonymity, and therefore could result in more honest responses,
- Statements or questions are phrased differently and same for all. This was expected to eliminate bias that normally occurs in interviews,
- May be used along with other data collection methods in a research study (Johnson & Christensen 2008:170), and therefore was used in conjunction with documentary analysis in this study to prove the authenticity of the results,
- Did not require personal interaction skills on the part of the researcher,
- The absence of face to face between the researcher and the respondents was assumed to reduce the effect on the responses,
- Could provide substantial amount of data that could be quantified, summarized and reported to all stakeholders (Learners, educators, principals, parents and department of education).

Though the questionnaire was considered to be the best research instrument for this study, it was very important to have well designed questionnaires in order to elicit in depth and more accurate data (Gay et al 2006:420, Borg et al 2005:313). This was achieved by spending much time on planning and developing both questionnaires, pre-testing them with friends, asking skilled people to evaluate them as well as piloting them in order to avoid lengthy, sloppy questionnaires with ambiguous questions or statements since such factors may turn respondents off (Johnson & Christensen 2008 :171).

**4.4.1 Design of Questionnaires.**

Two closed-ended questionnaires were developed for this study after completion of literature review. One questionnaire was for FET science educators (Appendix 2) while the other was for FET science learners (Appendix 3). In this study, the science educators' questionnaire was referred to as questionnaire A while the science learners' questionnaire was referred to as questionnaire B.

Questionnaire A consisted of 85 items while questionnaire B consisted of 40 items. The two questionnaires had some similarities and differences because they probed for specific information regarding the learners' views and opinions, and on the other hand the educators' views and opinions on what could be the factors associated with high failure rates in sciences at matriculation level. The major purpose of both questionnaires was to identify and establish the school based factors that cause high failure rates at matriculation levels in science by comparing the ideas, views and opinions of both science learners and science educators in order to come out with strategies of increasing and improving the performances of both learners and educators.

Closed-ended questions were used in both questionnaires because they specified a task and a range of possible responses such that the respondents were required to make a choice of an option from a set of numbered options. This provided a familiar format to respondents and made the completion of the items much easier and quicker. Besides being used to a large number of subjects, open-ended questions also used various and large numbers of items, generated more statistical data, which was straight forward to code and could be easily compared and analyzed (McMillan & Schumacher 2001 :257).

Open-ended questions were completely not included because of the following disadvantages which they could offer to this study (Johnson & Christensen 2008:176-177):

- Time consuming for respondents which could result in other items not completed.

- Are usually long and could reduce chances of the questionnaires being completed or in unreasonable and unreliable answers.
- Time consuming for researcher to code and quantify data.
- The questions used could be also difficult to code and analyze which could undermine the credibility of result.

Questions were closed-ended questions that required respondents to make a choice from biographical, organizational activities and its demographic elements listed. A rating scale, mostly the Likert scale (McMillan & Schumacher 2001:262) was used in both questionnaires to measure opinion, reaction, views and attitudes in relation to the statement. The Likert- type items were ideal in this study because they could use different response scales some of which were either neutral or directional.

A response alternative of *very poor, poor, average, good* to *very good* were applicable to some items in both questionnaires such as $V_{12}$ to $V_{20}$, $V_{23}$ to $V_{27}$ and $V_{45}$ to $V_{53}$ of questionnaire A, and $V_{13}$ to $V_{16}$ of questionnaire B. However a response of a *No* or a *Yes* was limited to few items in both questionnaires since responses were considered unable to provide the viewpoints of respondents and were requested only in $V_6$, $V_{11}$ and $V_{20}$ of questionnaire A and $V_7$ of questionnaire B.

Questionnaire A consisted of some items with four, five or six Likert scale response alternatives. Items such as $V_{30}$ and $V_{32}$ had four response alternatives that ranged from *very difficult to cope, relatively difficult to cope, cope relatively well,* to *cope very well* while $V_{38}$ to $V_{43}$ had response alternatives that ranged from *never, seldom, usually* to *always*. Item(s) with five response alternatives such as $V_{37}$ ranged from *very negative, negative, average, positive to very positive*. Those with six response alternatives ranged from *very poor, poor, average, good, very good* to *not applicable* ($V_{54}$ to $V_{63}$) and *strongly disagree, disagree, uncertain, agree, strongly agree* to *not applicable* ($V_{64}$ to $V_{86}$).

Questionnaire B consisted of not more than five Likert scale response alternatives. Those with five ranged from *strongly disagree, disagree,* *uncertain; agree* to *strongly agree* ($V_{17}$ to $V_{41}$), with the omission of a *not applicable* response which was in questionnaire A.

**4.4.2 Content of questionnaires.**

Questionnaire A (questionnaire for science educators) was divided into seven sections (Table 4.4) whilst questionnaire B (questionnaire for science learners) was divided into three sections only (Table 4.5). In all sections for both questionnaires, respondents were requested to make a choice from a list of alternative responses.

***4.4.2.1 Questionnaire A***

**Section 1** of this questionnaire requested for the biographical information of respondents with regard to gender, overall years of teaching experience, experience in teaching science at FET, highest qualifications, the subject(s) they majored in during their teacher training course and their post levels as science educators.

**Section 2** attempted to determine the availability of science resources such as human resources in terms of science educators who are qualified to teach at FET level, infrastructure such as classrooms and laboratories, furniture, science textbooks, laboratory equipment and consumables within the school as an organization.

In **Section 3**, questions and statements were formulated to find out whether the science educators knew the subject content very well and the principles of OBE which forms the new South African curriculum. Literature has shown that most science educators in South African schools have very little content knowledge and very shallow knowledge of how to teach science (Grayson 2010:10, Taylor 2009:13, Mji & Makgato 2006:259). Therefore the aim of such items in this section was to extend the work of these researchers so that it could be also tested on a larger sample of township high school science educators.

At FET, science consists of both physics and chemistry which involve mathematical calculations, therefore some items attempted to further probe if science educators possessed sufficient knowledge content required to teach learners in these three learning domains (physics, chemistry and mathematics).

The main focus of **section 4** of this questionnaire was to investigate whether educators use new or traditional teaching methods, how often they give learners tasks that require mathematical calculations, remedial teaching, expanded opportunities and language of teaching and learning they use. It further attempted to determine the educator-pupil ratio in the science class (class size), general attitude of learners towards science, the teaching load of the educator and whether they cope well teaching in such environments. In addition, the section tried to find out the engaged time in relation to the allocated time.

The skills of the educator are an important ingredient in teaching and learning of science. Therefore, **Section 5** consisted of statements to determine the skills of science educators in the following aspects: planning, supervision of learners during scientific activities, general classroom management (e.g. maintaining discipline), use of scientific equipment, recording, maintenance of equipment, motivation of learners and assessment skills.

**Section 6** requested the science educator to rate his head of science department in order to find out factors associated with the running of the department that may directly affect teaching and learning of science to take place. The items covered a wide range of aspects such as the science HoD's friendliness to science educators, his assistance to science educators, and his competence in science, ability to inspire science educators, planning of daily activities within the science department, supervision of science educators, communication skills, guidance and ordering of equipment.

**Section 7** was included as an opinion survey to determine the views of respondents about the teaching and learning process in general, their science department and the whole school as an organization. The statements were used to collect data which covered a wide range of aspects such as recognition, job satisfaction, opportunities for professional growth, team work, allocation of subjects according to subject(s) of specialization, positive support, respect of each other's suggestions, constructive feed back, equitable distribution of teaching loads and timetable which take into cognizance weak learners. Most of these aspects may have a direct impact on teaching and learning of science.

Some statements were also designed to gather data on the educators' feelings on whether they teach science for examination purposes only, whether they do experiments even if they may be dangerous, whether they allow learners to do experiments on their own even if they are time consuming and if equipment is fragile and whether they incorporate field trips in their teaching. Table 4.4 shows the variables, the content probed and the sections.

**Table 4.4: Content of questionnaire A**

| Section | Sectional Content | Variables |
|---|---|---|
| 1 | Biographical Information | $V_2$, $V_3$, $V_4$, $V_5$, $V_6$, $V_7$, $V_8$, $V_9$ |
| 2 | Availability of Resources | $V_{10}$, $V_{11}$, $V_{12}$, $V_{13}$, $V_{14}$, $V_{15}$, $V_{16}$, $V_{17}$, $V_{18}$, $V_{19}$, $V_{20}$ |
| 3 | Knowledge Base | $V_{21}$, $V_{22}$, $V_{23}$, $V_{24}$, $V_{25}$, $V_{26}$, $V_{27}$ |
| 4 | Teaching Methodologies, Class size, Engaged Time | $V_{28}$, $V_{29}$, $V_{30}$, $V_{31}$, $V_{32}$, $V_{33}$, $V_{34}$, $V_{35}$, $V_{36}$, $V_{37}$, $V_{38}$, $V_{39}$, $V_{40}$, $V_{41}$, $V_{42}$, $V_{43}$, $V_{44}$ |
| 5 | Educator's Skills | $V_{45}$, $V_{46}$, $V_{47}$, $V_{48}$, $V_{49}$, $V_{50}$, $V_{51}$, $V_{52}$, $V_{53}$ |
| 6 | Processes/activities in Science Department | $V_{54}$, $V_{55}$, $V_{56}$, $V_{57}$, $V_{58}$, $V_{59}$, $V_{60}$, $V_{61}$, $V_{62}$, $V_{63}$ |
| 7 | Processes/activities in School as Organization | $V_{64}$, $V_{65}$, $V_{66}$, $V_{67}$, $V_{68}$, $V_{69}$, $V_{70}$, $V_{71}$, $V_{72}$, $V_{73}$, $V_{74}$, $V_{75}$, $V_{76}$, $V_{77}$, $V_{78}$, $V_{79}$, $V_{80}$, $V_{81}$, $V_{82}$, $V_{83}$, $V_{84}$, $V_{85}$, $V_{86}$ |

#### *4.4.2.2 Questionnaire B*

**Section 1** of this questionnaire requested biographical information of respondents (learners) such as their grade, gender, age, whether they have personal scientific calculators and the number of times they have been absent from school.

**Section 2** attempted to investigate the respondents' views and feelings on the teaching methods applied to them by their science educators. In other words, the section intended to find out whether the science educator's teaching methods carters for the respondents' individual differences in terms of learning styles, language of communication, friendliness, helpfulness if they are struggling and ability to explain concepts clearly in a way that is understood by each respondent.

Some items in this section also tried to find out whether respondents could read and write in English without difficulties since science is always examined in English which is a second language to them. Furthermore, item $V_{12}$ attempted to probe whether respondents have difficulties in mathematics because science involves calculations in both physics and chemistry.

**Section 3** was included as an opinion survey to determine the feelings and opinions of respondents in terms of their interaction with the educator in class, how they view science as a subject, how the subject is taught to them, whether they are comfortable with the way they are taught, whether they feel that they are treated fairly, whether they feel that they are provided with opportunities which lead to their success and whether they feel that the homework and tasks given to them are fair and assessed fairly.

**Table 4.5: Content of questionnaire B**

| Section | Sectional Content | Variables |
|---|---|---|
| 1 | Biographical Information | $V_2$, $V_3$, $V_4$, $V_5$, $V_6$, |
| 2 | Learning Processes | $V_7$, $V_8$, $V_9$, $V_{10}$, $V_{11}$, $V_{12}$, $V_{13}$, $V_{14}$, $V_{15}$, $V_{16}$ |
| 3 | Learner and Educator Interactions | $V_{17}$, $V_{18}$, $V_{19}$, $V_{20}$, $V_{21}$, $V_{22}$, $V_{23}$, $V_{24}$, $V_{25}$, $V_{26}$, $V_{27}$, $V_{28}$, $V_{29}$, $V_{30}$, $V_{31}$, $V_{32}$, $V_{34}$ |

### 4.4.3 Reliability and Validity of instruments

Reliability and validity have always been seen as the most crucial criteria for evaluating quantitative research instruments such as questionnaires if the researcher's interpretation of data are to be valuable(Gay et al 2006 :134).

#### *4.4.3.1 Reliability.*

Reliability refers to the consistency of measurement, the extent to which the scores are similar over different forms of the same data instrument, or occasions of data collection (McMillan & Schumacher 2001:181). In other words, data collection is reliable if a researcher gets essentially the same data from observation to observation during any measuring instance or that varied from time to time for a given unit of analysis measured twice or more by the same instrument (Robson 2007:71). On the other hand, if different researchers administer the same instrument the same results should be obtained under comparable conditions.

In a nutshell reliability is concerned with the clarity, stability, quality, consistency, adequacy and accuracy of the measuring instrument which are questionnaires in this study. However, Robson (2007:71) goes further by saying that it is usually impossible to get an exact repetition of a measurement when working with people. Therefore to guard against reliability in this study, the measuring instrument was piloted, revised and given to experts for final checking.

#### *4.4.3.2 Validity.*

According to Johnson and Christensen (2008 :150-151) and McMillan and Schumacher (2001 :181) validity can be described as whether or not something actually measures what it claims to measure for particular people in a particular context and that the interpretations made on the basis of the test scores are correct. In this study, it was very important to consider both content and construct validity of the measuring instrument.

Johnson and Christensen (2008:151) describe construct validity as the one that involves relating a measuring instrument to a general theoretical framework in order to determine whether the instrument is tied to the concepts and theoretical assumptions that are employed while content validity is described as the degree to which a measuring instrument measures an intended content area.

To guard against validity, after drafting the measuring instruments they were given to colleagues, experts, experienced researchers and to the supervisor to check the validity of the instrument(questionnaires) before administering them. They assessed the inclusiveness, content and relevancy of the questions to the subject under study. This also helped to reveal any ambiguities and ensured both validity and reliability assisted the questionnaires to achieve the degree of precision necessary for respondents to understand exactly what was asked. Borg et al (2005: 313) believes that a well designed questionnaire can elicit in depth information.

#### *4.4.3.3 Pilot Study*

To enhance both validity and reliability of the research instruments, a pilot study was carried out. Bell (2005:147), and McMillan and Schumacher (2001:185) remind researchers that data gathering instruments should be piloted in order to:

- Guard against validity and reliability,
- Ensure that the questions mean the same to all respondents,
- Estimate how long it takes the respondents to complete the questions,
- Check that all the questions and instruments are concise and clear,
- Check ambiguity in sentence,
- Check biased items,
- Check problems that have been experienced so that the researcher can remove any items which do not yield usable data and ensures that the respondents experience no difficulties in completing the questionnaires, and
- Finally have direction.

Due to the aforementioned reasons a pilot study was therefore carried out in the township of Palm Springs, in the south of Johannesburg at one of the public high school where the researcher was employed as a science educator. The school was chosen for the pilot study because it was also a historically disadvantaged township public high school and hence was assumed to have similar characteristics with public high schools in Alexandra Township. Learners were also from poor socio-economic background just like learners in the main study. Since the school was in a different district it was assumed that no contamination of the main study would occur.

As depicted in Table 4.6(i) and (ii), questionnaires were self-administered to 6 FET science learners and 3 FET science educators. Extreme case sampling method was used to select two learners from each grade for the pilot study. To guard against gender bias, one boy and one girl who performed badly in June exams were chosen from each grade (grade 10, 11 and12) since the study was looking at poor performance of learners.

**Table 4.6: Pilot study responses**

(i)

| Questionnaire B | Sent | Received | % Returned |
|---|---|---|---|
| Grade 10 Learners | 2 | 2 | 100 |
| Grade 11 Learners | 2 | 2 | 100 |
| Grade 12 Learners | 2 | 2 | 100 |
| **Total** | **6** | **6** | **100** |

(ii)

| Questionnaire A | Sent | Received | % Returned |
|---|---|---|---|
| Science Educators | 3 | 3 | 100 |
| **Total** | **3** | **3** | **100** |

The questionnaire for science educators was completed within a range of 15 to 25 minutes while that one for science learners was completed within a time frame of 10 to 15 minutes. Both educators and learners were requested to comment on the time they spent to complete the questionnaires and whether there were questions which were not clear and difficult to answer. They all indicated that the questions were clear and understandable and could be completed in reasonable period of time.

However the instructions on questions were rather confusing to the respondents though the respondents did not indicate that. It was discovered when the researcher was going over the responses made by respondents that some proceeded to insert an X where the instructions to the next question asked them to encircle. This was corrected by restructuring the instructions so that the respondents could insert an X for every response through out the questionnaires. Instructions on all items were corrected to ensure reliability and validity.

## 4.5 Data Collection

As far as data collection is concerned, the higher the percentage of returned questionnaires the better the data (Gay et al 2006:170). Robson (2007:43) strongly warns that many surveys suffer from poor response. Therefore to safe guard against this, and obtain a 100 percent response rate, which Gay et al (2006:171) recommends as a very excellent response rate, the questionnaires were self-administered to the subjects.

Since the letter from the Department of Education granted the researcher permission to be at each school for two consecutive days (appendix 4), the first day at each school was used by the researcher to introduce himself to the principal of the school and explain the purpose of his research study, collect lists of learners for grades 10, 11 and 12 as well as making necessary arrangements with the head of science department and science educators. Day two was used for self-administering and completion of questionnaires. Both educators and learners completed the questionnaires in the presence of the researcher and the questionnaires were immediately collected after completion. Besides obtaining a 100 percent response rate, self-administering of questionnaires also gave the researcher an opportunity to further elaborate the purpose of the study, to establish rapport and clear misunderstandings. In addition it also gave the researcher a chance to judge the seriousness with which the respondents took the whole exercise which was also a useful basis in the interpretation of results.

It is generally accepted and recommended that researchers should not only rely on a single strategy and source of data collection method (Gay et al 2006:446). In addition, questionnaires have some limitations since they tend to be more effective at obtaining general information rather than detailed information. Therefore, to guard against this, the triangulation method which was mainly based on documentary analysis was also applied to a small number of learners and educators who quickly finished their questionnaires.

Triangulation is described as the use of multiple data collection strategies and sources to provide additional, deeper and powerful safeguards (Gay et al 2006:405, Robson 2007:70, Bell 2005:116) so that evidence obtained may lead to convergence, corroboration and correspondence of results from different methods (Johnson & Christensen 2008 :451).

In this study, triangulation was employed by examining the work given to learners in their exercise books and portfolio files to check if the tasks given to learners were of appropriate standard, enough, marked or marked on time. This was done by checking the work of any four learners who quickly finish completing the questionnaire in each grade (grade 10, 11 and 12) for the two schools. Similarly two educators who completed their questionnaires first per each school were requested to give the researcher their files to check their lesson plans, the level of content given to learners in tests and record of marks. This means that a total of twenty four learners' exercise books and four educators' files were examined. The triangulation method was employed:

- So that the weaknesses which could be in the questionnaires were compensated by the strength of the documentary analysis method, (Gay et al 2006:443).
- To inevitably obtain different perspective on the data collected from the main method(questionnaire method) and compare it with the experiences of educators and learners as indicated in their work,
- To get a clear picture of what could be the causes of high failure rate in science by cross-checking information from different angles(Bell 2005 :116),
- This was assumed to substantially increase the credibility or trustworthiness of the research findings (Johnson & Christensen 2008:451) on causes of high failure rates in sciences.

## 4.6 Data Analysis

Data analysis is described by Gay et al (2006:5) as a systematic organization and synthesis of data that involves application of one or more statistical techniques. It therefore gives meaning to data collected during research in a way that permits the researcher to answer the research question. Data was analyzed on the basis of the responses given by respondents. A total of 250 of the learners' questionnaires and 10 of the educators' questionnaires were completed and collected. The researcher examined each of the response patterns and data was analyzed on the basis of the responses given by respondents (Gay et al 2006:172).

Descriptive statistics that involves frequencies and percentages derived from mathematical formulas were used to analyse and organise data and to represent all observations (McMillan and Schumacher 2001: 207). Inferential statistics were used to discuss the results since the research required the estimation of a population characteristic from an available sample of subjects.

## 4.7 Ethical Considerations

According to McMillan and Schumacher (2001:196) the term ethics refers to a set of principles that people use to decide what is right and what is wrong or what is good or bad. Johnson & Christensen (2008: 101,118-119 ) goes further by identifying the following ethical issues which researchers should take into cognizance: informed consent, avoidance of harm, violation of privacy, anonymity and confidentiality, deceiving respondents, respect of human dignity of which encompass right for full disclosure and debriefing respondents which he reminds any one who is involved in research to be aware of.

In this study permission was acquired from the Department of Education (District Office) to conduct research in all public high schools by writing a letter (Appendix 1). Permission to conduct research was granted by the Department of Education (District Office) and a written confirmation to the principals of schools was offered (Appendix4). Applications to conduct research (Appendix

5) together with letters for permission to conduct research from the District Office were self-delivered to the principals of schools. Responses from the principals of the selected schools were positive.

Ethical measures undertaken included informed consent of the entire subjects. According to Johnson & Christensen (2008:112) informed consent is the procedure in which individuals choose whether to participate in an investigation after being informed of the facts that would be likely to influence their decision. In this study respondents were assured of anonymity and confidentiality. The purpose and the procedures of the study were explained to learners and educators involved before questionnaires were self-administered. Anonymity was ensured by telling the respondents not to write their names on questionnaires. The respondents were told that their participation was voluntary and that they had the right to withdrew from the study at any time if they so wished.

## 4.8 Summary

This chapter discussed in details the research design, population and sampling design that were used in this research study. It further discussed data collection instruments, detailed strategies for the data collection process, reliability and validity of data collection instruments. In addition, it covered the pilot study which was carried out, permission for research and ethical measures that were adhered to. The next chapter deals with the analysis and the interpretation of the results obtained from both the learners' questionnaire and the educators' questionnaire.

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# CHAPTER 5: DATA ANALYSIS AND PRESENTATION

## 5.1 Introduction

This chapter concentrates on analysis and presentation of data. It presents the views and opinions of respondents regarding the school related factors that cause high matriculation failure rates in science in public high schools of Alexandra Township. Against the background of the literature review, the views and opinions of respondents, as they are reflected in answers from the two questionnaires that directed the study, are analyzed, summarized, organized and presented.

### 5.1.1 Procedure of Data Analysis and Presentation

Questionnaire A was directed to FET science educators while questionnaire B was directed to FET science learners. Therefore data analysis and presentation is done according to the views and opinions of both FET science educators and FET science learners.

Views and opinions of respondents were analyzed statistically and results were presented either as pie charts, bar graphs or tables. For the sake of discussion of tables, where participants were asked to rate each item based on a five point Likert-scale of *very poor*, *poor*, *average*, *good* and *very good*, the values attributed to *very poor* and *poor* were grouped and considered as lack of or unsatisfactory where as the *good* and *very good* values combined were noted as enough of or satisfactory.

With regard to the tables where items were rated according to the Likert-scale of *strongly disagree*, *disagree*, *uncertain*, *agree* and *strongly agree* the values attributed to *strongly disagree* and *disagree* were grouped together while those attributed to *agree* and *strongly agree* were likewise combined for the purpose of discussion. Descriptive statistics was used to report the results.

It is from this data analysis that school related factors that cause high matriculation failure rates in science are obtained and possible solutions are offered. Furthermore, recommendations are formulated as reflected in the responses to the questionnaires and in current literature respectively which could lead to the alleviation of some of the restrictions presently hampering successful teaching and learning of science at matriculation level in public high schools of South African townships.

### 5.1.2 Respondents.

Since both questionnaires were self-administered, all the questions were answered by the respondents as unclear items were clarified to them. Furthermore, all questionnaires were immediately collected after completion. Table 5.1 indicates the general response rate for both questionnaires, providing a combined response rate of 100 percent, which is considered excellent (Gay et al 2008:117).

**Table 5.1: Questionnaires sent out and returned in the main study.**

| Questionnaire | Number sent out | Number received |
|---|---|---|
| Questionnaire A | 10 | 10 |
| Questionnaire B | 250 | 250 |

It is noticeable from Table 5.1 that the study had a relatively small number of participants for questionnaire A (n=10) as compared to a relatively large number of participants for questionnaire B (n=250). Therefore the results were analyzed separately to obtain what each sub-sample perceived as school related factors that causes high matriculation failure rates in science, starting with those of questionnaire A and then followed by those of questionnaire B.

## 5.2 Data Analysis and Presentation of Questionnaire A.

The purpose of this section is to present the information obtained from questionnaire A. The statistical information presented was obtained from 10 questionnaires completed by the FET science educators.

### 5.2.1 Biographical Information of FET Science Educators.

A brief personal profile of FET science educators is provided in this section. This information was obtained from section 1 of questionnaire A and includes:

- Gender
- Overall years of teaching experience
- Years of experience in teaching of science at FET (grades 10, 11 and 12)
- Highest qualification obtained in science at high school

- Highest teaching qualifications
- Subject majored during teacher training course
- Post level as a science educator

#### *5.2.1.1 Gender of educators.*

The gender of science educators is an important aspect during the interpretation of the results in this study. It is important to see how many female respondents participated in the study to determine if they will provide any significantly different views from male respondents. Figure 5.1 presents data regarding the gender of science educators.

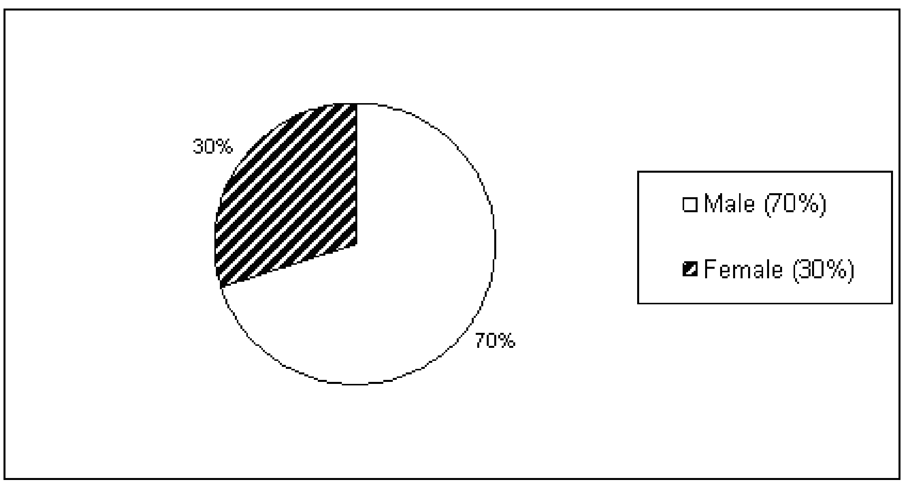


**Figure 5.1: Gender of educators.**

An analysis of the gender profile of the respondents indicates that the science educator population is still dominantly male (70%, n=7) since only 30% (n=3) were females. This correlates with most literature and research studies in the field of science which suggests that the scientific oriented professions are male dominated since females are usually less involved in science and frequently experience barriers to immersion into culture of science as compared to males (Pop, Dixon & Grove 2010:133, Unisa 2010:1, Trowbridge et al 2004: 286).

### *5.2.1.2 Overall years of teaching experience.*

Teaching experience which in this study, refers to the knowledge and skills gained through length of time spent in the teaching profession (South Africa 2003: 9), is a very important aspect that influences the educator's effectiveness in the teaching of science. Figure 5.2 consists of data concerning the responses of science educators regarding the overall length of time they had been teaching.

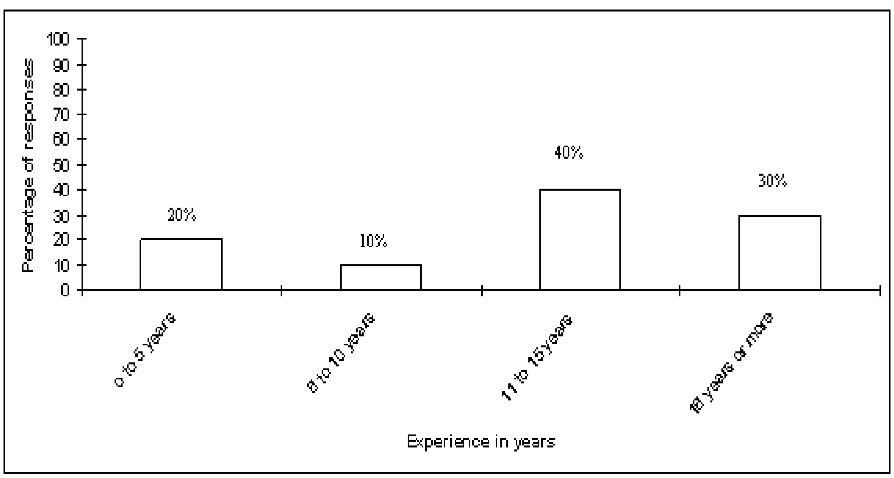


**Figure 5.2: Educators' overall years of teaching experience.**

Figure 5.2 shows that the largest group of respondents of 40% (n=4) had between 11 to 15 years of teaching experience. This is followed by 30% (n=3) with 16 years or more of teaching experience. This group may be regarded as the most experienced group of science educators and in turn may be considered to provide a solid background for classroom teaching and learning. Such educators may among other various roles become experts in: mediating the learning process as well as interpreting and designing the Learning Programmes and materials through their experience, as compared to novice educators (South Africa 2003:5).

The smallest group of 10% (n=1) comprised of science educators within the range of 6 to 10 years experience of teaching. For the purpose of this study science educators within a range of 0 to 5 years teaching experience are regarded as the least experienced group and comprised of 20% (n=2).

#### *5.2.1.3 Experience in teaching science at FET level.*

Although the learning outcomes are the same in the South African science curriculum for all grades (South Africa 2002:29-30, South Africa 2003: 13-14), experience in teaching science at FET provides science educators with the necessary knowledge and skills that are required in teaching science at FET level since there is progression from simple to complex in terms of content, knowledge, skills and context from one grade to another (South Africa 2003:3). Figure 5.3 illustrates teaching experience at FET level.

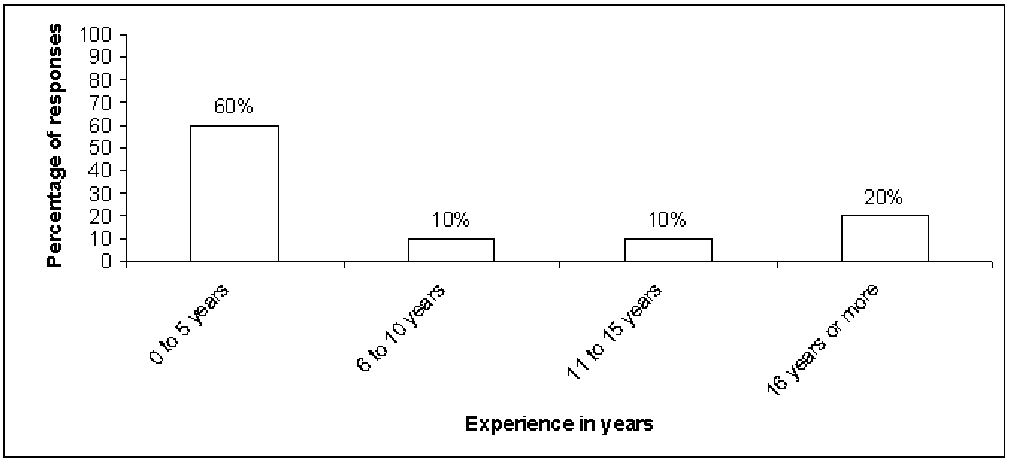


**Figure 5.3: Experience in teaching science at FET level.**

It is indeed worrying to observe in Figure 5.3 that over half of the educators, (60%, n=6) had the least experience of teaching science at FET which ranges between a period of 0 to 5 years. This is followed by 20% (n=2) of the educators who rated themselves as having the longest experience of teaching science at FET for a period of 16 or more years. The two smallest groups, which are equally distributed, consisted of 10% (n=1) each and comprised of science educators within a range of 6 to 10, and 11 to 15 years experience of teaching science at FET.

#### *5.2.1.4 Highest qualifications obtained in science at high school.*

The depth of the content of science at high school differs depending on whether one has done science at standard grade, higher grade, Cambridge "O" level or Cambridge "A" level, etcetera. Table 5.4 shows distribution of teachers by matriculation type.

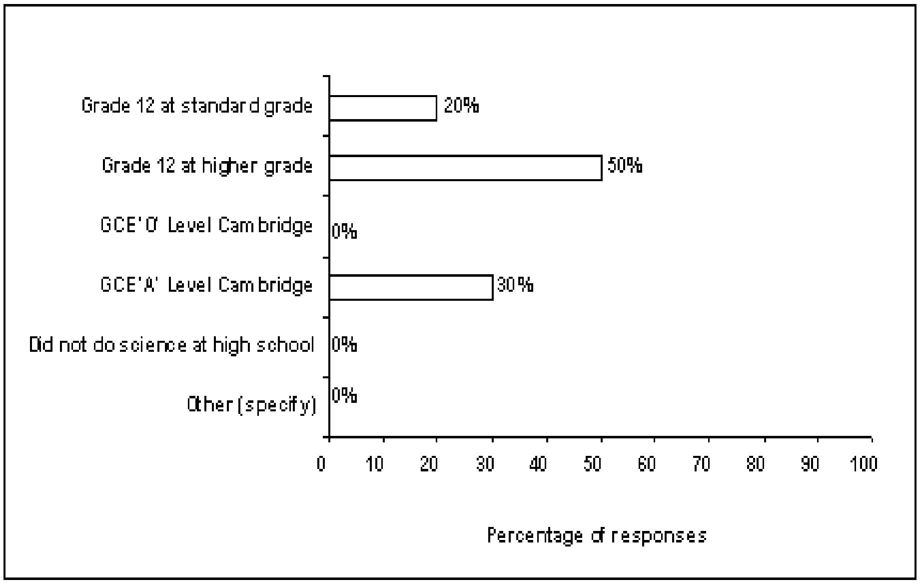


**Figure 5.4: Highest qualifications in science at high school.**

Data in Figure 5.4 reveals that 50% (n=5) of the science educators had done their high school science at higher grade while 30% (n=3) did their high school science at "A" level Cambridge. It can also be noted that the least group of 20% (n=2) did their high school science at standard grade while none (0%) did their science at GCE 'O' level or other.

This information suggests that a total of 80% (n=8) of science educators had done science at both higher grade and "A" level Cambridge which in this study is considered to provide an extensive and stronger background in science as compared to 20% (n=2) who did science at standard grade. The later was considered to cover superficial scientific concepts and provided little value thereafter, since it was believed to deny learners many life-chances (South Africa 2008:4).

### *5.2.1.5 Highest teaching qualifications of educators.*

It is encouraging that all science educators (100%, n=10) responded with a *yes* while 0% (n=0) responded with a *no* to the question: Are you a qualified science educator ($V_6$)? As a follow up to this question, Figure 5.5 presents the results with regard to the highest teaching qualifications of science educators and thus provides their knowledge and skill base.

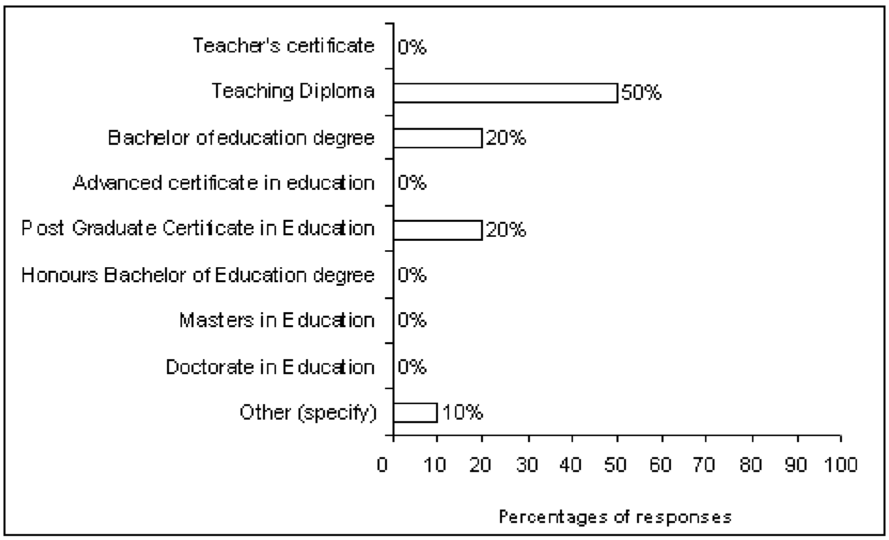


**Figure 5.5: Highest teaching qualifications of educators.**

It is very important to highlight that 50% (n=5) of the respondents indicated that they had a Diploma in Education as their highest teaching qualification. In this study, a Diploma in Education is considered to provide lower content knowledge of the subject as compared to Post Graduate or Degree level. Two uniformly distributed groups of 20% (n=2) each, indicated that they had a Bachelor of Education Degree and a Post Graduate Certificate in Education respectively as their highest qualifications.

It is disconcerting to note that 10% (n=1) rated themselves as having the other qualification namely a Higher National Diploma in Civil Engineering, which is rather more suitable for industrial purposes than classroom teaching. Furthermore, none (n=0) of the respondents rated themselves as having an Honours Bachelor of Education degree, a Masters degree or a Doctorate degree in Education as their highest qualifications which in the context of this study, may be regarded as very important qualifications in the teaching of high school science that provide extensive content and skills in both scientific and mathematical concepts which are abstract as well as in-depth pedagogical knowledge.

#### *5.2.1.6 Subject(s) of specialization.*

Specialization in one subject during teacher training course provides in-depth and extensive knowledge and skills such that one becomes an expert in that particular subject. Figure 5.6 gives a general picture of science educators' responses on the subject(s) they specialized in, during their teacher-training course.

It can be noted that 10% (n=1) of respondents majored in science only. This may imply that only a negligible number of science educators are experts in science. A closer analysis of this figure also indicates that the majority of respondents (60%, n=6) majored in both science and mathematics. From the teaching of science standpoint, this is encouraging as both subjects (mathematics and science) are cornerstones for the teaching and learning of science.

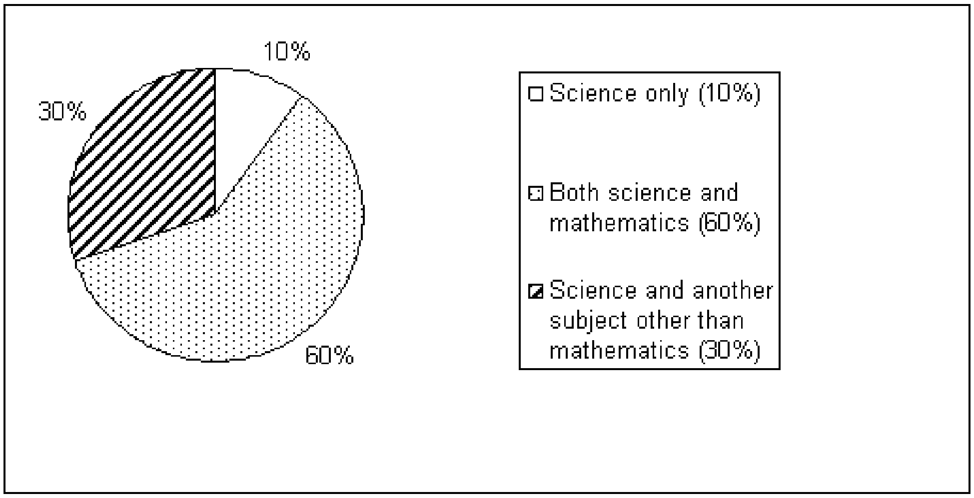


**Figure 5.6: Educators' subject(s) of specialization.**

Surprisingly, 30% (n=3) of the respondents majored in science and another subject other than mathematics, which in addition, is not related to both science and mathematics nor plays any role in the development of scientific concepts and skills.

Although such educators taught science and were regarded as science educators, their knowledge of the subject matter may not be comparable to those educators who specialized in science only or science and a related subject such as mathematics.

Variable 9 ($V_9$) further asked the science educators to indicate their post levels. They all (100%, n=10) rated themselves as post level 1 science educators. This implies that no post level 2 science educators (heads of science department) participated in this study.

### 5.2.2 Aspects Related to Availability of Resources.

This section of the questionnaire attempted to find out the extent to which science educators rated the availability of different resources in their schools that are important for the successful teaching and learning of science.

#### *5.2.2.1 Availability of laboratories.*

Variable 10 ($V_{10}$), illustrated in figure 5.7 attempted to obtain the responses of educators with regard to the availability of laboratories in their schools.

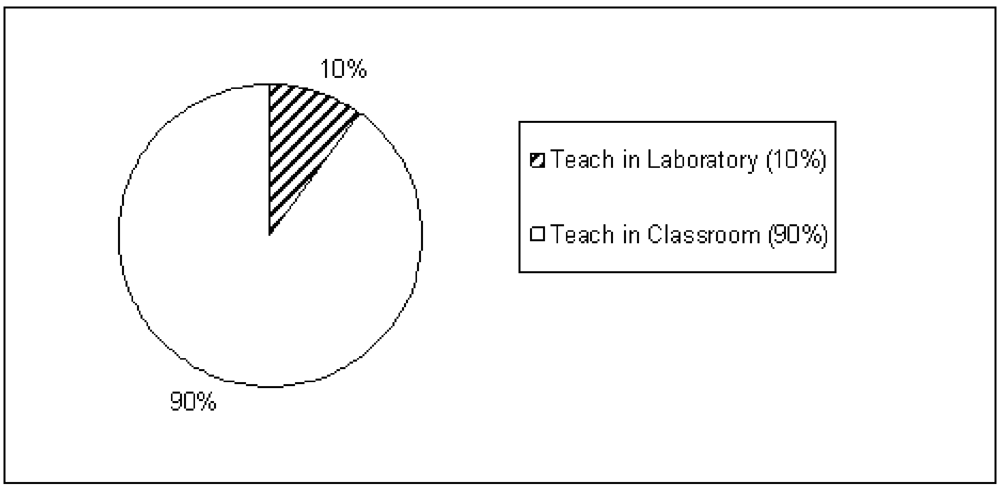


**Figure 5.7: Educators' responses on availability of laboratories.**

Data in figure 5.7 shows that the majority of science educators (90%, n=9) taught in classrooms while only 10% (n=1) taught in laboratories. This suggests that most schools do not have laboratories and this may result in lack of exposure of learners to practical work.

#### *5.2.2.2 Availability of material resources.*

Variables in Table 5.2 further attempt to ascertain the availability of other various resources which are important for the teaching and learning of science on a five Likert rating scale of *very poor*, *poor*, *average*, *good* and *very good*.

For the sake of discussion the values in Table 5.2 attributed to *very poor* and *poor* were grouped together and considered as lack of resources whereas the *good* and *very good* values combined were noted as enough resources.

By analyzing Table 5.2, it is worth noticing that the majority of the educators indicated deficiencies of science resources as a dominant factor in their schools. Resources that were rated as in serious shortages (*very poor* or *poor*) included: science text books for the new curriculum (90%, n=9), chemicals for chemistry practicals (70%, n=7), equipment for physics practicals (70%, n=7), tables/ desks for learners to perform experiments (70%, n=7), chairs for science learners to sit (60%, n=6) and tables/desk for science learners to write on (60%, n=6).

Resources that were rated as enough or adequate (*good* or v*ery good*) by science educators included: national curriculum statements (100%, n=10), science charts (70%, n=7) and human resources qualified to teach science at FET (70%, n=7). Although this reveals a high percentage of educators qualified to teach at FET, it may be possible to indicate that most of them had little experience of teaching science at FET (Figure 5.3) and were not subject experts (Figure 5.6).

Generally, it can be noted from Table 5.2 that the schools are under-resourced to such an extent that successful teaching and learning of science is hampered in this particular Township.

**Table 5.2: Educators' responses on resource availability.**

| RESOURCES | n | RATING OF RESOURCES ON A SCALE OF 1 TO 5 | | | | | TOTAL |
|---|---|---|---|---|---|---|---|
| | % | VERY POOR | POOR | AVERAGE | GOOD | VERY GOOD | |
| Chemicals for chemistry practicals | n | 4 | 3 | 2 | 0 | 1 | 10 |
| | % | 40 | 30 | 20 | 0 | 10 | 100 |
| Equipment for physics practicals | n | 3 | 4 | 0 | 2 | 1 | 10 |
| | % | 30 | 40 | 0 | 20 | 10 | 100 |
| Chairs for science learners to sit | n | 4 | 2 | 3 | 1 | 0 | 10 |
| | % | 40 | 20 | 30 | 10 | 0 | 100 |
| Tables or desks for science learners to write on | n | 3 | 3 | 2 | 0 | 2 | 10 |
| | % | 30 | 30 | 20 | 0 | 20 | 100 |
| Tables or desks for learners to perform experiments | n | 5 | 2 | 2 | 1 | 0 | 10 |
| | % | 50 | 20 | 20 | 10 | 0 | 100 |
| Science text books for the new curriculum (NSC) | n | 6 | 3 | 1 | 0 | 0 | 10 |
| | % | 60 | 30 | 10 | 0 | 0 | 100 |
| National curriculum statement documents (FET) | n | 0 | 0 | 0 | 2 | 8 | 10 |
| | % | 0 | 0 | 0 | 20 | 80 | 100 |
| Science educators qualified to teach at FET | n | 0 | 0 | 3 | 1 | 6 | 10 |
| | % | 0 | 0 | 30 | 10 | 60 | 100 |
| Science charts | n | 1 | 0 | 2 | 3 | 4 | 10 |
| | % | 10 | 0 | 20 | 30 | 40 | 100 |

### 5.2.3 Aspect related to knowledge content of the subject.

Variable 21 ($V_{21}$) asked respondents to assess and rate their knowledge base in physics and chemistry, which are the two main domains of science at FET level. Figure 5.8 shows that half of the respondents (50%, n=5) had difficulties in teaching both physics and chemistry, whereas two groups which are equally distributed, rated themselves as having problems either in chemistry (20%, n=2) or physics (20%, n=2). It is disconcerting to note that the least group and negligible group of 10% (n=1) had no difficulties in both domains of science.

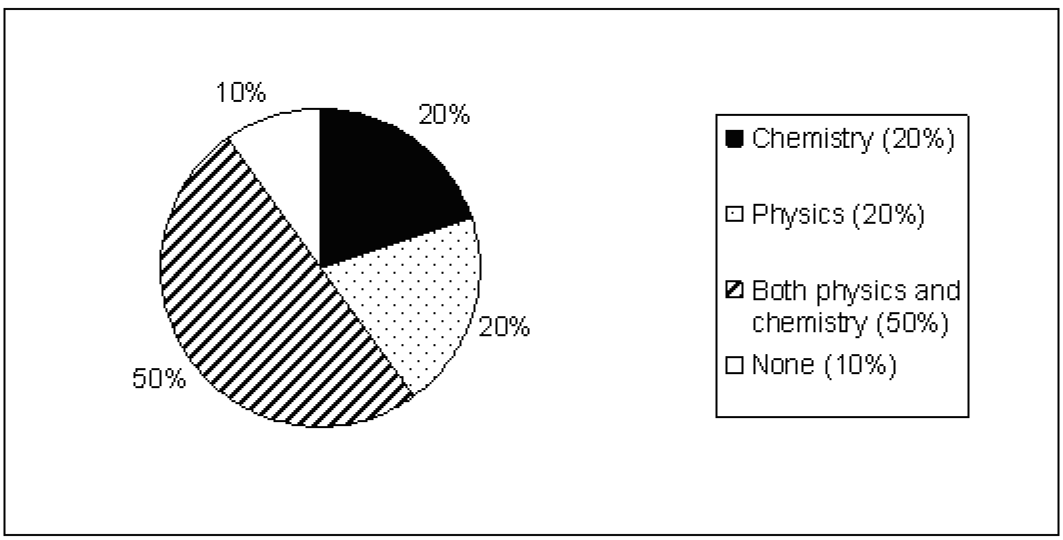


**Figure 5.8: Knowledge content of educators in physics and chemistry.**

It can be concluded from Figure 5.8 that far more than half the respondents have superficial background of both physics and chemistry which are the two domains of science at FET level. Although most educators in Table 5.2 indicated that they were qualified to teach science at FET, lack of in-depth knowledge content in both the main domains of science (Figure 5.8) could be attributed to the difficulty in teaching science at FET level and hence poor achievements by science learners at matriculation level.

As a follow up to this, variable 22 ($V_{22}$) attempted, to find out whether science educators have adequate mathematical background required for teaching science since science at FET level involves lots of calculations and uses mathematics as a vehicle for delivering most concepts. In Figure 5.9 it is alarming to note that 30% (n=3) of the respondents indicated that the mathematical part was very difficult to teach while an additional 40% (n=4) regarded the mathematical part of science as relatively difficult. Only a negligible amount of 10% (n=1) indicated that mathematics was relatively easy while 20% (n=2) regarded it as very easy.

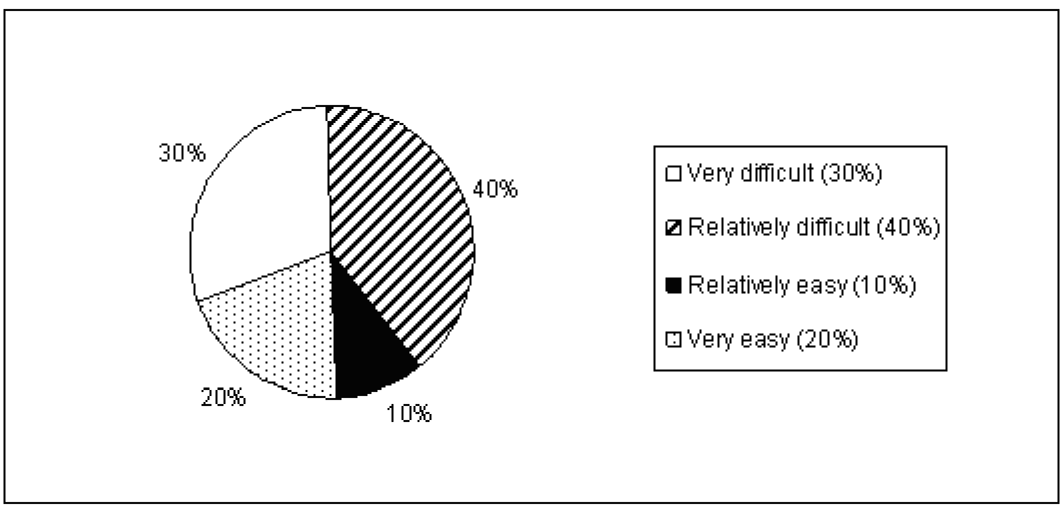


**Figure 5.9: Educators' responses on how difficult they find the mathematical part of science.**

These responses are consistent with responses provided in Table 5.3, which further indicate how science educators rated themselves on other variables related to their knowledge capacity. Educators rated themselves as deficient in the following knowledge areas: new curriculum terminology (50%, n=6), OBE principles (30%, n=3) and new teaching methods where the learner is actively involved in activities of the science lesson while the educator facilitates (20%, n=2).

It is however encouraging in Table 5.3 to note that 80% (n=8) of the respondents rated themselves as having the ability to answer subject related questions that learners ask while 50% (n=5) rated themselves as having the knowledge of the subject matter. However, one may further argue that the ability to answer the learners' questions and having the knowledge of the subject matter does not necessarily mean that the science educator has the extensive and in-depth knowledge of the subject content and skills that are required at FET level.

It is also clear from Table 5.3 that 60% (n=6) of educators rated themselves as having average knowledge on OBE principles. Further analysis indicates that two equal groups of educators rated themselves as average in the following knowledge areas: Knowledge of the subject matter (50%, n=5) and new teaching methods where the learner is actively involved while the educator facilitates (50%, n=5).

A cumulative percentage of 42% rated themselves as having average knowledge in most knowledge aspects.

**Table 5.3: Responses of educators on aspects related to knowledge capacity.**

| KNOWLEDGE | n | KNOWLEDGE RATING ON SCALE OF 1 TO 5 | | | | | TOTAL |
|---|---|---|---|---|---|---|---|
| | % | VERY POOR | POOR | AVERAGE | GOOD | VERY GOOD | |
| Knowledge of subject matter | n | 0 | 0 | 5 | 3 | 2 | 10 |
| | % | 0 | 0 | 50 | 30 | 20 | 100 |
| Ability to answer subject related questions that learners ask | n | 0 | 0 | 2 | 6 | 2 | 10 |
| | % | 0 | 0 | 20 | 60 | 20 | 100 |
| New teaching methods where learner is actively involved while educator facilitates | n | 0 | 2 | 5 | 3 | 0 | 10 |
| | % | 0 | 20 | 50 | 30 | 0 | 100 |
| The new curriculum terminology | n | 1 | 4 | 3 | 1 | 1 | 10 |
| | % | 10 | 40 | 30 | 10 | 10 | 100 |
| OBE Principles | n | 0 | 3 | 6 | 1 | 0 | 10 |
| | % | 0 | 30 | 60 | 10 | 0 | 100 |

### 5.2.4 Aspects related to the workload.

Data in figure 5.10 was obtained from variable 28 ($V_{28}$), and reveals that 60% (n=6) of the respondents taught science subject only. It is also clear that nearly half of the science educators (40%, n=4) taught science and another subject and this implies that such educators have more work to prepare, teach and mark for two different subjects, which could result in overburdening.

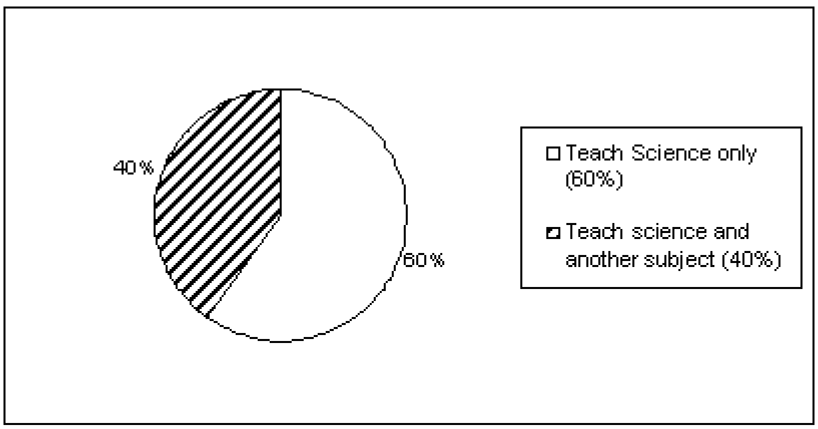


**Figure 5.10: Educators' responses towards subject allocation.**

The overburdening of science educators is further revealed in figure 5.11 which gives a summary of their responses regarding the average number of science learners (class sizes) they teach in each grade ($V_{29}$). It is clear that the average class sizes of science learners are very large since 50% (n=5) of the respondents rated themselves as teaching 46 or more learners in their classes. This is followed by 40% (n=4) who rated themselves as teaching classes between the ranges of 31 to 45. Still this average number of learners in a class is fairly large and gives reason for concern since it points to the existing cases of too large science classes

(South Africa 2009 :8-9). Only 10% (n=1) of science educators indicated that they taught classes of 30 or less learners which compares quite favorably with the average learner-educators ratio in some independent schools (South Africa 2009 :9).

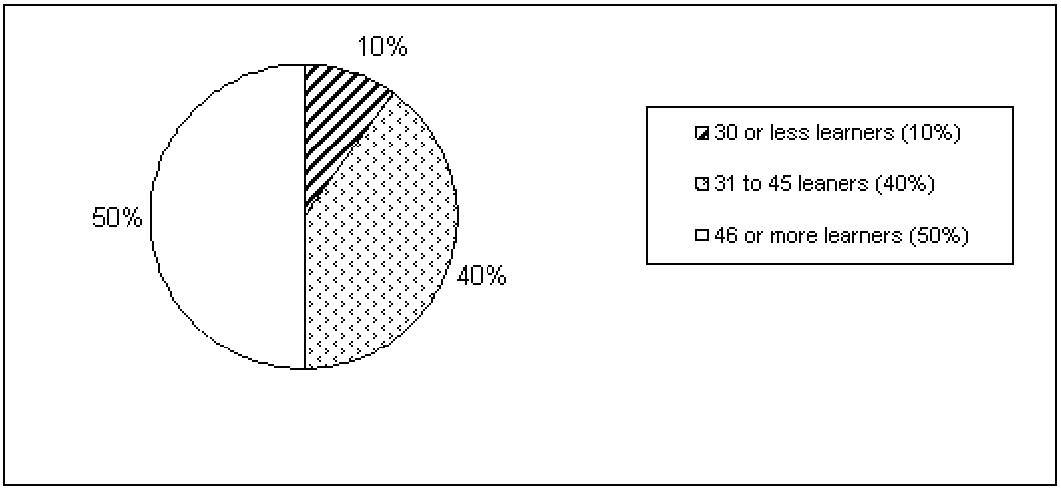


**Figure 5.11: Educators' responses on class sizes.**

As a follow-up on the question about the number of learners in a class, $V_{30}$ attempted to find out how well science educators cope with teaching the number of learners in their classes. Figure 5.12 reflects that 40% (n=4) of the respondents found it very difficult to cope teaching their class sizes, while an equally distributed group (40%, n=4) of respondents showed that it was relatively difficult to cope with their class sizes. It is indeed very worrying to note that only 20% (n=2) rated themselves as coping relatively well with their class sizes while none (0%, n=0) coped very well.

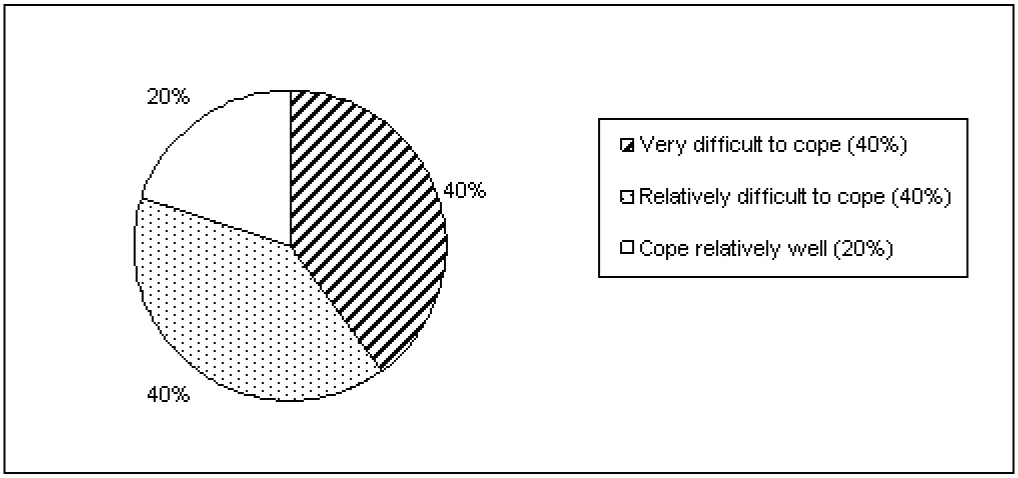


**Figure 5.12: Educators' responses on coping with class sizes.**

To have a further clear picture of how science educators were overburdened, variable 31 ($V_{31}$) was asked so that they indicate the number of periods they teach per week. They supplied the information concerning the total number of their teaching periods devoted per week as indicated in Figure 5.13.

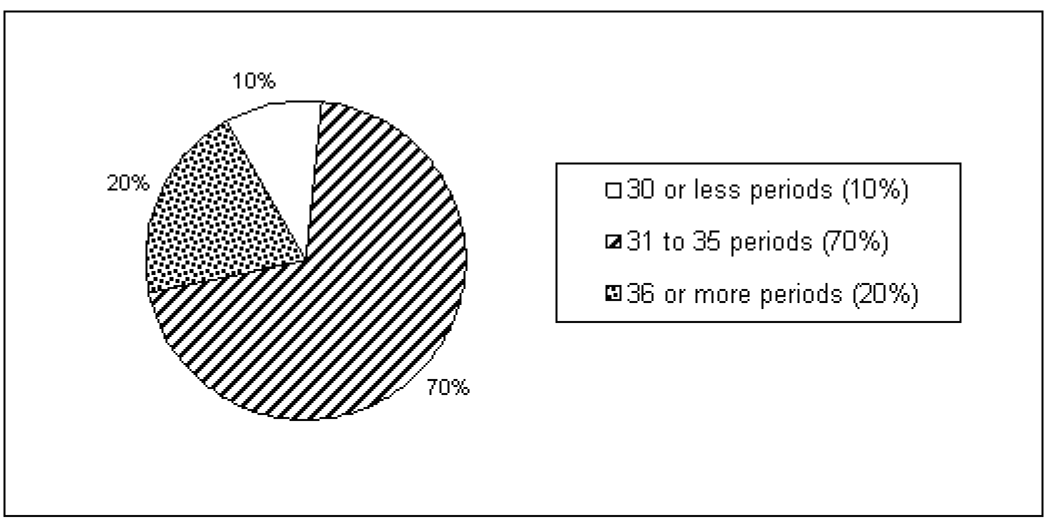


**Figure 5.13: Educators' responses towards number of periods they teach per week.**

It is established from Figure 5.13 that 70% (n=7) taught between the ranges of 31 to 35 periods per week while 20% (n=2) taught between the ranges of 36 or more periods. Too many periods per week leave educators without free periods to do administrative duties, follow up work, and prepare experiments and change apparatus and aids they use. Only 10%, (n=1) of the respondents had 30 or fewer periods per week which is considered to be a fair number of periods since educators can have free periods between lessons to do necessary preparations for next lessons as well as other administrative work.

These responses are in consistent with responses provided by science educators in variable 32 ($V_{32}$) where they were asked to indicate how well they cope with the number of lessons they taught per week.  Figure 5.14 shows that 50% (n=5) of the educators found it very difficult to cope teaching the periods allocated to them while 20% (n=2) found it relatively difficult to cope. This may be attributed to overburdening. However, only 30% (n=3) rated themselves as coping relatively well while none (0%, n=0) rated themselves as coping very well.

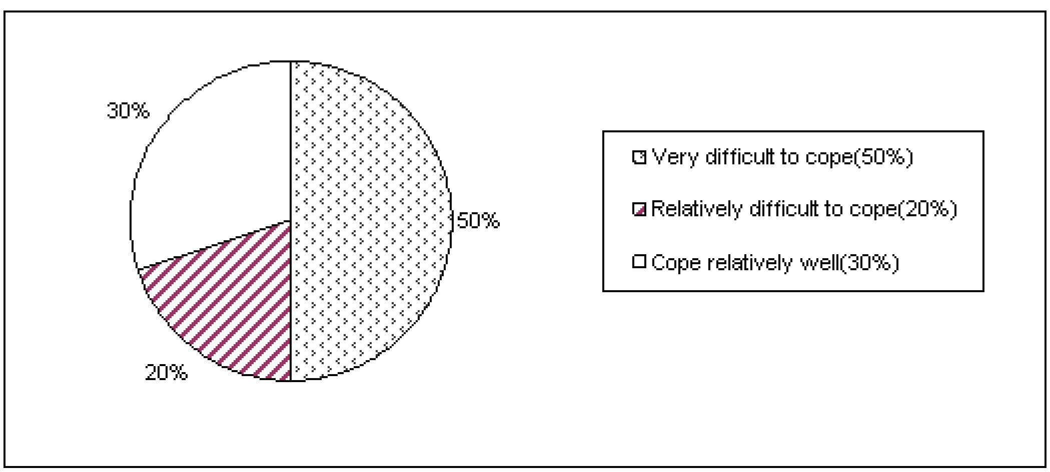


**Figure 5.14: Educators' responses on coping with the allocated periods.**

### 5.2.5 Aspect related to language of instruction

Variable 35 ($V_{35}$) attempted to find out the language of instruction frequently used by science educators during the lessons. Figure 5.15 consists of data concerning the responses of educators to the language of instruction they frequently use.

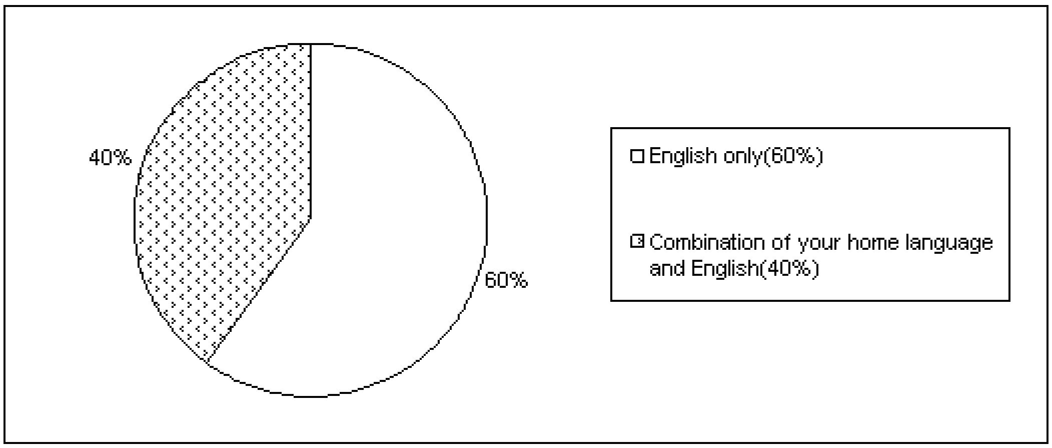


**Figure 5.15: Educators' responses towards the language of instruction.**

The information shows that 60% (n=6) of the science educators use English only as the language of instruction during science lessons. It maybe possible to attribute this larger group to the fact that most science educators who teach physical science at FET level are hired from foreign countries (Chibaya 2007 :3) and are not familiar with the local languages and hence use English only. It is also clear from the results that 40% (n=4) of the educators use both English and their own (educator's) home languages. None (0%, n=0) indicated that they either used their home language only or other languages. It is also important to highlight that other languages in this case may refer to the learner's home language which the educator may not be familiar with.

Interestingly, one may ask whether using English only as a medium of instruction is an effective way of teaching science since 79.2% of science learners in questionnaire B, (Figure 5.30) indicated that they experienced difficulties in reading English while another 76% experienced difficulties in writing English. Furthermore, confusion, misunderstandings and communication barriers may arise which may be exacerbated if the science educator combines both English and his own home language (40%, n=4) as shown in Figure 5.15, particularly in the case where the learner is not familiar with the educator's home language since South Africa has eleven official languages. In addition, most of the abstract concepts in science are expressed and communicated mathematically. Figure 5.16 shows how often the educators give learners mathematical problems in science so that they practice and are able to express and communicate abstract concepts mathematically.

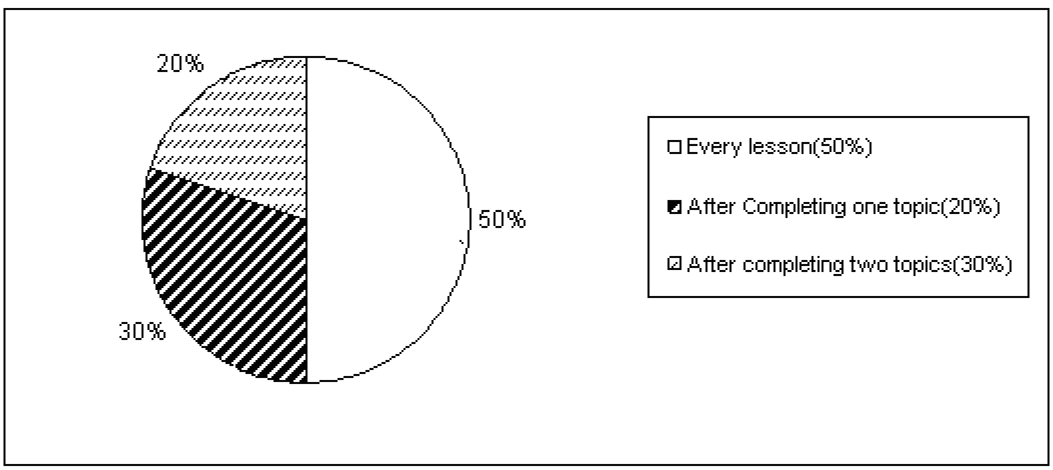


**Figure 5.16: Educators' responses on how often they give mathematical problems.**

It is encouraging to note that 50% (n=5) of the educators give learners mathematical problems after every lesson. This provides enough practice for mathematical skills required for communicating abstract concepts in science. It is however worrying that 30% (n=3) of the educators give learners mathematical problems after completing the whole topic while 20% (n=2) give them after completing two topics.

### 5.2.6 Aspect related to learner's attitude towards science

Figure 5.17 shows that 10% (n=1) of the educators rated their learners as having a very positive attitude towards science while 20% (n=2) rated them as having a positive attitude. Although 40% (n=4) rated their learners as being average in their attitude towards science it is rather disturbing to note that 10% rated their learners as having a negative attitude while 20% (n=2) rated them as having a very negative attitude towards science.

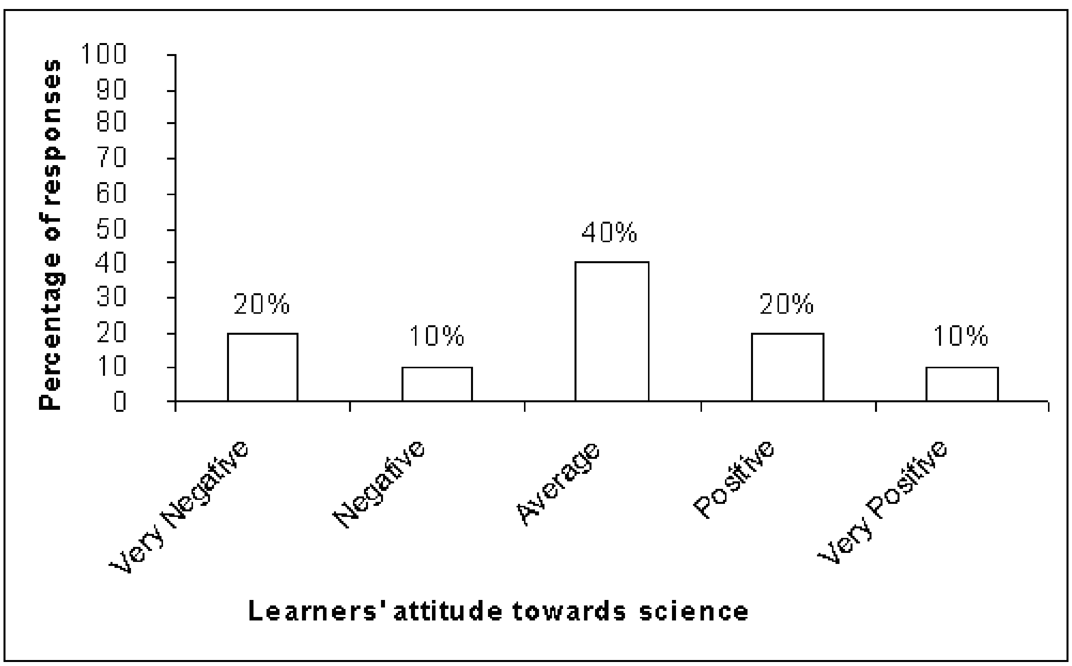


**Figure 5.17: Educators' responses on learner's attitude towards science.**

### 5.2.7 Aspects related to time management.

$V_{11}$ attempted to probe whether each science educator has an allocated classroom. The idea was to find out whether the learners or educators move during the change of the lessons and then determine time wasted during change of the lesson. As indicated in Figure 5.18, 90% (n=9) of educators responded with a *yes* while 10% (n=1) responded with a *no* to the question: do you have an allocated science classroom? This implies that a greater proportion of learners had to move to their educators' classrooms during the change of the lessons resulting in congestion and delays in corridors and ultimately less teaching time.

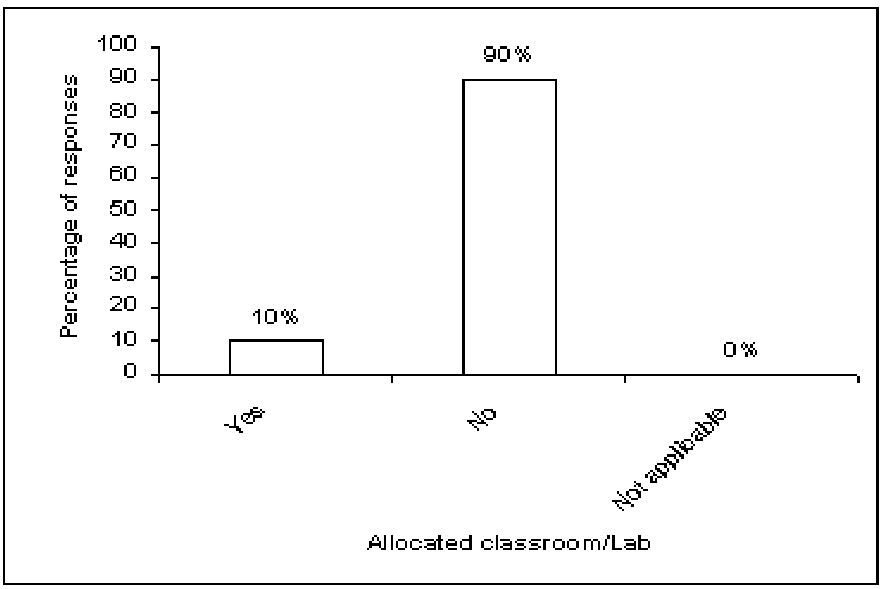


**Figure 5.18: Educators with an allocated classroom/laboratory**

$V_{34}$ further attempted to find out the time spent by learners as they move to their educators' classrooms during the change of the lessons. Figure 5.19 shows that

60% (n=6) of the educators rated their learners as spending time within a range of 0 to 5 minutes to get to their classrooms while 10% (n=1) rated their learners as spending time within a range of 6 to 10 minutes during the change of the lesson. It is rather shocking to note that 20% (n=2) rated their learners as spending time between ranges of 11 to 15 minutes while 10% (n=1) rated them as spending 16 or more minutes to get to their classrooms for the lessons.

This implies that much of the teaching and learning time is spent on movement of learners from the previous lesson to the next science lesson.

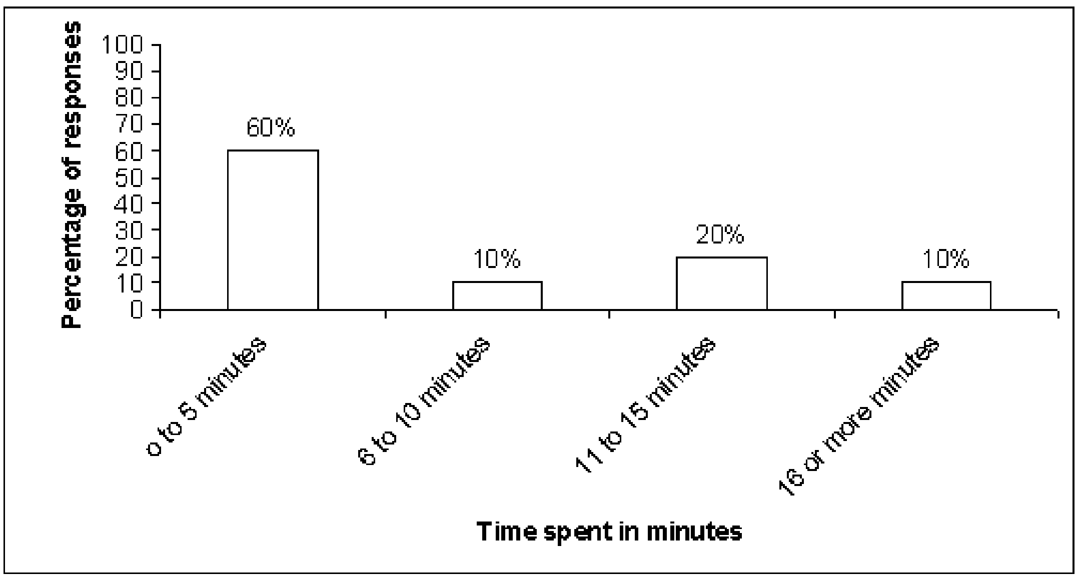


**Figure 5.19: Educators' responses on time spent during the change of lessons.**

Since much time is spent during change of lessons, it may be presumed that a double science lesson is better than a single lesson. This is because in a double lesson, some of the time is left to provide: learners with time to settle down, the educator with time to explain and give instructions and for individual learners to do activities and manipulate the apparatus.

Figure 5.20 shows that 90% (n=9) of educators had double science lessons on their timetables while 10% (n=1) had single periods.

However, delays during the change of the lessons (Figure 5.19) leaves insufficient time for broad and extensive learning experiences in lessons.

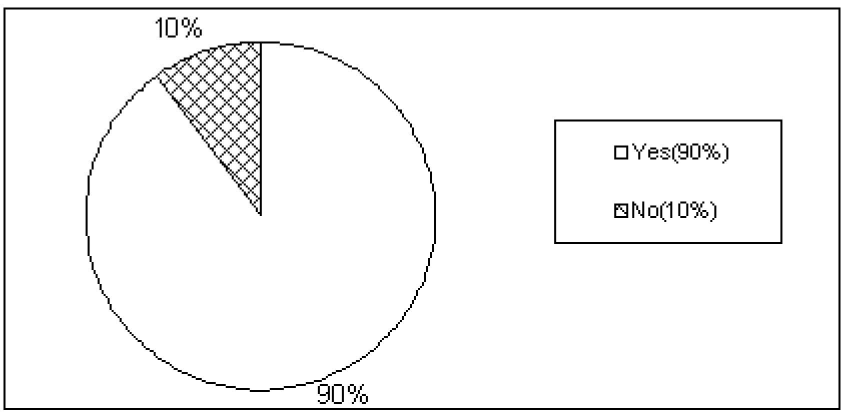


**Figure 5.20: Educators with double lessons in science.**

### 5.2.8 Aspect related to absenteeism.

High levels of absenteeism as shown in Figure 5.21 further affects the teaching time. It is clear that by the time the questionnaires were administered, 40% (n=4) of educators had been absent from school for ranges 1 to 5 days while 20% (n=2) had been absent for ranges between 6 to 10 days. It is however concerning that 30% (n=3) of the educators had been absent for ranges 11 to 15 days while 10% (n=1) had been absent for 16 days or more.

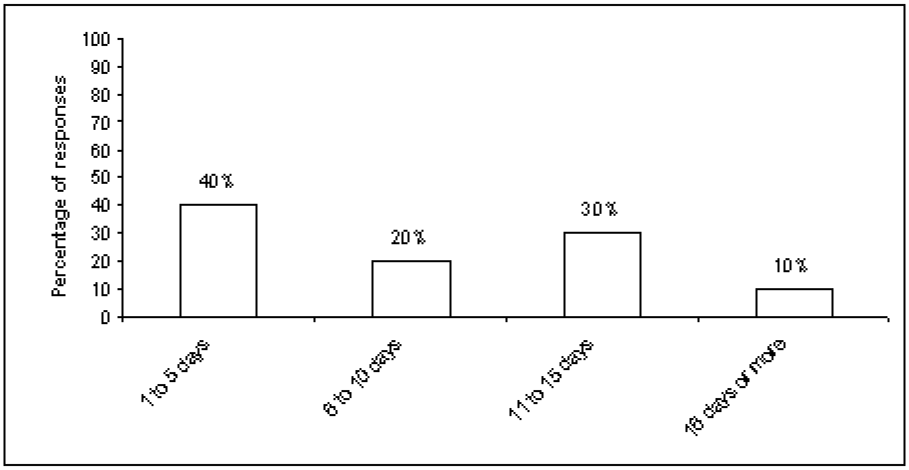


**Figure 5.21: Educator's level of absenteeism.**

### 5.2.9 Aspect related to the educators' teaching methods.

Table 5.4 consists of educators' responses on variables that attempted to investigate matters related to their teaching methods. Their responses were recorded according to a four Likert-rating scale of *never*, *seldom*, *usually* and *always*. For the sake of discussion of Table 5.4, the values attributed to *never* and *seldom* were grouped together and considered as unsatisfactory whereas the *usually* and *always* values were noted as satisfactory.

It is encouraging to note that some educators in Table 5.4 satisfactorily applied the following methods: succeed in capturing learners' interest in the learning material (100%, n=10), offer remedial teaching (70%, n=7) and expanded opportunities (50%, n=5).

It is however distressing to note that none (0%, n=0) of the educators satisfactorily used the teaching methods that allow learners to discover the lesson content by using interesting teaching strategies. It even worries more to depict from Table 5.4 that some educators unsatisfactorily applied the following teaching methods: use of a variety of teaching methods (70%, n=7), succeed in capturing the learner' interest in the learning material (70%, n=7), remedial teaching (50%, n=5), expanded opportunities (50%, n=5) and make use of different learning activities (30%, n=3).

It may be possible to accept that the introduction of the NCS has added to the problem. For example, in the NCS, the educators are introduced to new topics based on the principles of Outcomes-Based Education (OBE) which describes learning from the perspective of the learner (South Africa 2003 :13-14, South Africa 2008 :2).

This implies that educators are compelled to use new skills in teaching and learning of science. Some of the skills that are now required in science include the ability to teach and assess the investigative methods and the relationship of science to humankind and the environment (South Africa 2003: 14, South Africa 2008 :2-3). In this regard, even qualified educators lack skills required by this new approach since such skills have never been taught. Although one may applaud the NCS for focusing explicitly on exposing learners to higher order thinking in science, its flaws such as over-emphasis of assessment and the associated administration have also created problems of prescribing appropriate teaching strategies.

**Table 5.4: Responses related to educators' teaching methods.**

| TEACHING METHODS | n / % | RATING TEACHING METHODS ON SCALE OF 1 TO 4 | | | | TOTAL |
|---|---|---|---|---|---|---|
| | | NEVER | SELDOM | USSUALY | ALWAYS | |
| Use a variety of teaching methods | n | 7 | 1 | 2 | 0 | 10 |
| | % | 70 | 10 | 20 | 0 | 100 |
| Allows learners to discover the lesson content by using interesting teaching strategies | n | 0 | 0 | 4 | 6 | 10 |
| | % | 0 | 0 | 40 | 60 | 100 |
| Succeed in capturing learner's interest in the learning material | n | 4 | 3 | 1 | 2 | 10 |
| | % | 40 | 30 | 10 | 20 | 100 |
| Make use of different learning activities | n | 2 | 1 | 6 | 1 | 10 |
| | % | 20 | 10 | 60 | 10 | 100 |
| Remedial teaching | n | 4 | 1 | 4 | 1 | 10 |
| | % | 40 | 10 | 40 | 10 | 100 |
| Expanded opportunities | n | 3 | 2 | 2 | 3 | 10 |
| | % | 30 | 20 | 20 | 30 | 100 |

### 5.2.10 Aspect related to the educators' organizational skills.

Variables in Table 5.5 asked respondents to assess their skills in their positions as science educators according to six alternative rating scales. For the sake of discussion of Table 5.5, the values attributed to *very poor* and *poor* were grouped together and considered as lack of skill whereas the *good* and *very good* values were noted as adequate in skill or satisfactory.

The majority of educators rated their skills as satisfactory: in motivation of learners during the science lesson (70%, n=7), use of science resources/ equipment (60%, n=6) and recording and filing (50%, n=5). Respondents also rated themselves as average in skills such as planning of a science lesson (70%, n=7) and supervision of learners during experiments (50%, n=5).

It is however disconcerting to note that quite a number of respondents rated themselves as unsatisfactory in skills such as: Maintaining of science equipment/ apparatus (70%, n=7), assessment of their own weaknesses and strength (40%, n=4), assessment of learners' weaknesses and strength (30%, n=3) and classroom management (30%, n=3).

It can therefore be concluded that not all science educators have the required skills that allow them to provide effective teaching and learning of science in their classrooms.

**.Table 5.5: Educators' responses on aspects related to their organizational skills.**

| ORGANISATIONAL SKILL | n / % | RATING OF ORGANISATIONAL SKILLS ON SCALE OF 1 TO 5 | | | | | TOTAL |
|---|---|---|---|---|---|---|---|
| | | VERY POOR | POOR | AVERAGE | GOOD | VERY GOOD | |
| Planning of a science lesson | n | 0 | 0 | 7 | 0 | 3 | 10 |
| | % | 0 | 0 | 70 | 0 | 30 | 100 |
| Supervision of learners during experiments | n | 0 | 1 | 5 | 2 | 2 | 10 |
| | % | 0 | 10 | 50 | 20 | 20 | 100 |
| Classroom management during a science lesson | n | 2 | 1 | 3 | 2 | 2 | 10 |
| | % | 20 | 10 | 30 | 20 | 20 | 100 |
| Use of resources/ equipments | n | 3 | 0 | 1 | 4 | 2 | 10 |
| | % | 30 | 0 | 10 | 40 | 20 | 100 |
| Assessment of learners' weaknesses and strength | n | 1 | 2 | 2 | 2 | 3 | 10 |
| | % | 10 | 20 | 20 | 20 | 30 | 100 |
| Motivation of learners during the science lesson | n | 0 | 3 | 4 | 3 | 0 | 10 |
| | % | 0 | 30 | 40 | 30 | 0 | 100 |
| Maintaining of science equipment/apparatus | n | 4 | 0 | 3 | 2 | 1 | 10 |
| | % | 40 | 0 | 30 | 20 | 10 | 100 |
| Recording and filing | n | 0 | 1 | 2 | 4 | 3 | 10 |
| | % | 0 | 10 | 20 | 40 | 30 | 100 |
| Assessment of your own weaknesses and strength | n | 5 | 2 | 3 | 0 | 0 | 10 |
| | % | 50 | 20 | 30 | 0 | 0 | 100 |

### 5.2.11 Aspect related to the head of science department's management skills.

The head of science department should have basic managerial skills such as planning, organizing, leading, and controlling and communication skills. In addition, he is also expected to have extensive and in-depth knowledge of the subject content and its policy since all are integral aspects of effective teaching and learning of science within the whole department. Table 5.6 listed variables that are applicable to the management skills of the head of science that can lead to effective teaching and learning within the department. Educators rated their head of science on a six Likert- rating scale. For the sake of discussion, the percentages of negative values (*very poor* and *poor*) were combined whereas the percentages of positive values (*good* and *very good*) were also combined.

Positive responses were obtained in the following traits of the heads of science: Helpfulness to science educators (60%, n=6), ability to inspire science educators (50%, n=5) and decision making within the science department (40%, n=4), planning of daily activities within the science department (30%, n=3), friendliness to science educators (30%, n=3) and ordering of equipment (30%, n=3).

However, most respondents provided more negative responses to same statements by rating the skills of their head of science department as *very poor* or *poor*. Highest scores of negative responses that are equally distributed were recorded in the following statements: competence in science (60%, n=6), communication skills within the science department (60%, n=6) and decision making within the science department (60%, n=6).

Furthermore, more negative responses that are uniformly distributed were recorded in skills of the heads of science such as guidance of science educators (50%, n=5) and planning of daily activities within the science department (50%, n=5). It is also important to highlight that supervision of educators and learners (40%, n=4), ability to inspire science educators (40%, n=4), ordering of science equipment (30%, n=3) and friendliness to science educators (20%, n=2) also received negative responses.

Educators rated their heads of science as average with highest scores in the following traits: friendliness to science educators (50%, n=5) and supervision of science educators or learners (40%, n=4).

It can also be noted that a few statements were rated as *not applicable* by some educators and included the following: Guidance of science educators (20%, n=2), ordering of science equipment (10%, n=1) and planning of the daily activities within the science department (10%, n=1).

It may be possible to conclude that such skills were rated as *not applicable* by some educators because the heads of science in the particular schools did not possess the skills.

**Table 5.6: Educators' responses on aspects related to the head of department science's management skills**

| SKILL OF HEAD OF SCIENCE DEPARTMENT | n | RATING OF SKILLS ON SCALE OF 1 TO 6 | | | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|
| | % | VERY POOR | POOR | AVERAGE | GOOD | VERY GOOD | NOT APPLICABLE | |
| Friendliness to science educators | n | 0 | 2 | 5 | 1 | 2 | 0 | 10 |
| | % | 0 | 20 | 50 | 10 | 20 | 0 | 100 |
| Helpfulness to science educators | n | 1 | 0 | 3 | 4 | 2 | 0 | 10 |
| | % | 10 | 0 | 30 | 40 | 20 | 0 | 100 |
| Competence in science | n | 6 | 0 | 3 | 1 | 0 | 0 | 10 |
| | % | 60 | 0 | 30 | 10 | 0 | 0 | 100 |
| Ability to inspire science educators | n | 2 | 2 | 1 | 0 | 5 | 0 | 10 |
| | % | 20 | 20 | 10 | 0 | 50 | 0 | 100 |
| Planning of daily activities within the science department | n | 3 | 2 | 1 | 1 | 2 | 1 | 10 |
| | % | 30 | 20 | 10 | 10 | 20 | 10 | 100 |
| Supervision of science educators or learners | n | 1 | 3 | 4 | 0 | 2 | 0 | 10 |
| | % | 10 | 30 | 40 | 0 | 20 | 0 | 100 |
| Communication skills within the science department | n | 4 | 2 | 3 | 1 | 0 | 0 | 10 |
| | % | 40 | 20 | 30 | 10 | 0 | 0 | 100 |
| Decision making within the science department | n | 5 | 1 | 0 | 3 | 1 | 0 | 10 |
| | % | 50 | 10 | 0 | 30 | 10 | 0 | 100 |
| Guidance of science educators | n | 1 | 4 | 1 | 2 | 0 | 2 | 10 |
| | % | 10 | 40 | 10 | 20 | 0 | 20 | 100 |
| Ordering of science equipment | n | 2 | 1 | 3 | 1 | 2 | 1 | 10 |
| | % | 20 | 10 | 30 | 10 | 20 | 10 | 100 |

### 5.2.12 Opinion survey

Mainly, this section attempted to find out the opinions of the science educators on different variables listed. They had to indicate the extent to which they agree to the variables indicated. For the purpose of discussion, the variables were classified into different aspects such as those related to the teaching methods (Table 5.7), workload and reward (Table 5.8) as well as the management and leadership style by the head of science department (Table 5.9). A six Likert- rating scale of *strongly disagree, disagree, uncertain, agree, strongly agree* and *not applicable* was used to rate each statement. For the sake of discussion, the percentages of negative values (*strongly disagree and disagree*) were combined whereas the percentages of positive values (*agree and strongly agree*) were also combined.

#### ***5.2.12.1 Extent to which educators agree on aspects related to their teaching methods***

Table 5.7 indicates the extent to which science educators agree on aspects related to their teaching methods. It is clear from Table 5.7 that the respondents stated that they *strongly disagree* or *disagree* to the following statements: I do experiments in science even if these may be dangerous (60%, n=6), I allow learners to perform certain experiments even if it is my responsibility should accidents occur (50%, n=5), I give learners opportunities to use equipment even if it is expensive (50%, n=5) and I use only the lecture method in class (50%, n=5).

On the other hand, respondents *agreed* or *strongly agreed* with the following statements: I teach science at Matric for examination purposes only (70%, n=7), I always use homework effectively to reinforce what is learned in class (100%, n=10), I use only the lecture method in class (50%, n=5) and I give my learners a chance to scrutinize their own performance to identify where they need help (100%, n=10).

Table 5.7 also shows that some of the respondents were uncertain to the following statements: I assess learners according to the departmental policy (40%, n=4), Field trips are important (20%, n=2), I give learners opportunities to use equipment even if it is expensive (10%, n=1) and I allow learners to do experiments even if it takes time (10%, n=1).

In addition, other respondents indicated that the following statements were not applicable to them: I allow learners to do experiments even if it takes time (20%, n=2), I teach science at Matric for examination purpose only (10%, n=1), I do experiments in science even if these may be dangerous (10%, n=1) and I allow learners to perform certain experiments even if it is my responsibility should accidents occur (10%, n=1).

It may be possible to conclude that the teaching methods associated with variables rated with *uncertain* and *not applicable* were either not performed at all or not effectively performed.

**Table 5.7: Extent to which educators agree on aspects related to their teaching methods.**

| TEACHING METHODS | n / % | Strongly Disagree | Disagree | Uncertain | Agree | Strongly agree | Applicable | TOTAL |
|---|---|---|---|---|---|---|---|---|
| | | TEACHING METHODS ON A RATING SCALE OF 1 TO 6 | | | | | | |
| I teach science at Matric for Examination purpose only | n | 0 | 2 | 0 | 5 | 2 | 1 | 10 |
| | % | 0 | 20 | 0 | 50 | 20 | 10 | 100 |
| I allow learners to do experiments even if it takes time | n | 3 | 1 | 1 | 3 | 0 | 2 | 10 |
| | % | 30 | 10 | 10 | 30 | 0 | 20 | 100 |
| I do experiments in science even if these may be dangerous | n | 4 | 2 | 0 | 1 | 2 | 1 | 10 |
| | % | 40 | 20 | 0 | 10 | 20 | 10 | 100 |
| I allow learners to perform certain experiments even if it is my responsibility if accidents occur | n | 2 | 3 | 0 | 2 | 2 | 1 | 10 |
| | % | 20 | 30 | 0 | 20 | 20 | 10 | 100 |
| I give learners opportunities to use equipment even if it is expensive | n | 5 | 0 | 1 | 2 | 2 | 0 | 10 |
| | % | 50 | 0 | 10 | 20 | 20 | 0 | 100 |
| Field trips are important | n | 1 | 3 | 2 | 3 | 1 | 0 | 10 |
| | % | 10 | 30 | 20 | 30 | 10 | 0 | 100 |
| I always use home work effectively to reinforce what is learned in class | n | 0 | 0 | 0 | 4 | 6 | 0 | 10 |
| | % | 0 | 0 | 0 | 40 | 60 | 0 | 100 |
| I use only the lecture method in class | n | 3 | 2 | 0 | 4 | 1 | 0 | 10 |
| | % | 30 | 20 | 0 | 40 | 10 | 0 | 100 |
| I give my learners a chance to scrutinize their own performance to identify where they need help | n | 0 | 0 | 0 | 5 | 5 | 0 | 10 |
| | % | 0 | 0 | 0 | 50 | 50 | 0 | 100 |
| I assess learners according to the departmental policy | n | 1 | 2 | 4 | 2 | 1 | 0 | 10 |
| | % | 10 | 20 | 40 | 20 | 10 | 0 | 100 |

### *5.2.12.2 Extent to which educators agree on aspects related to their workload and reward.*

Table 5.8 represents the science educators' responses on aspects regarding their workload, recognition and reward. Over half the number of respondents provided negative responses to these variables. They either strongly disagreed or disagreed with the following statements: I am satisfied with my salary as a science educator (90%, n=9), OBE principle has little paper work (90%, n=9), my overall teaching load is fair (80%, n=8), hardworking science educators are recognized at my school (70%, n=7) and that the school timetable permits me to spent time with weaker learners (70%, n=7).

On the other hand a group of 30% (n=3) agreed or strongly agreed to the following statement: The school timetable permits me to spend time with weaker learners. It can also be noted that two equally distributed groups of 20% (n=2) each were in agreement (agreed or strongly agreed) to the following statements: My overall teaching load is fair and that hardworking science educators are recognized at my school. It is however worrying to note that 0% (n=0) of the educators agreed or strongly agreed to the statements that: I am satisfied with my salary as a science educator and that OBE principle has little paper work. It is also important to highlight that two more uniformly distributed groups of educators were uncertain to the following statements: OBE principles has little work (10%, n=1) and that, I am satisfied with my salary as a science educator (10%, n=1).

**Table 5.8: Extent to which educators agree to aspects related to their workload and reward.**

| WORK LOAD AND REWARD | n | WORKLOAD ON A RATING SCALE OF 1 TO 6 | | | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|
| | % | STRONGLY AGREE | DISAGREE | UNCERTAIN | AGREE | STRONGLY AGREE | NOT APPLICABLE | |
| The school time table permits me to spend time with weaker learners | n | 4 | 3 | 0 | 2 | 1 | 0 | 10 |
| | % | 40 | 30 | 0 | 20 | 10 | 0 | 100 |
| My overall teaching load is fair | n | 6 | 2 | 0 | 1 | 1 | 0 | 10 |
| | % | 60 | 20 | 0 | 10 | 10 | 0 | 100 |
| OBE principles has little paper work | n | 8 | 1 | 1 | 0 | 0 | 0 | 10 |
| | % | 80 | 10 | 10 | 0 | 0 | 0 | 100 |
| Hard working science educators are recognized at my school | n | 5 | 2 | 0 | 1 | 1 | 1 | 10 |
| | % | 50 | 20 | 0 | 10 | 10 | 10 | 100 |
| I am satisfied with my salary as a science educator | n | 7 | 2 | 1 | 0 | 0 | 0 | 0 |
| | % | 70 | 20 | 10 | 0 | 0 | 0 | 100 |

### *5.2.12.3 Extent to which educators agree with aspects related to management and leadership style of the head of science.*

Interpersonal relations, team work, positive support, constructive feedback and opportunities for professional growth are important elements of effective teaching and learning in the science department that depend on the management and leadership style of the head of science. Table 5.9 indicates the extent to which science educators agree on aspects related to the management and leadership style by the head of science department in schools.

Interestingly, 60% (n=6) of the educators *agreed* or *strongly agreed* that their heads of science department listen to suggestions of other science educators and 40% (n=4) strongly agreed or agreed that the way their schools are run make it easier for them to perform their duties. However, more than half of the science educators were in disagreement (strongly disagreed or disagreed) with the following statements: my head of the science department provides constructive feedback (80%, n=8), my head of science department provides positive support (60%, n=6), science educators at this school work as a team (60%, n=6) and that my head of science department tries hard to figure out how to do things in the proper way (50%, n=5). It can further be noted that 40% (n=4) were in disagreement with the statement that opportunities for professional growth were available in their schools.

**Table 5.9: Extent to which educators agree to aspects related the management and leadership style by the head of science department.**

| MANAGEMENT AND LEADERSHIP STYLE | n / % | MANAGEMENT AND LEADERSHIP STYLE ON A RATING SCALE OF 1 TO 6 | | | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|
| | | STRONGLY DISAGREE | DISAGREE | UNCERTAIN | AGREE | STRONGLY AGREE | NOT APPLICABLE | |
| Science educators at my school are provided with necessary support | n | 3 | 1 | 2 | 2 | 1 | 1 | 10 |
| | % | 30 | 10 | 20 | 20 | 10 | 10 | 100 |
| Science educators at this school work as team | n | 2 | 4 | 0 | 1 | 2 | 1 | 10 |
| | % | 20 | 40 | 0 | 10 | 20 | 10 | 100 |
| Opportunities for professional growth are available at my school | n | 1 | 3 | 2 | 2 | 1 | 1 | 10 |
| | % | 10 | 30 | 20 | 20 | 10 | 10 | 100 |
| My head of the science department listens to the suggestions of other science educators | n | 2 | 2 | 0 | 2 | 4 | 0 | 10 |
| | % | 20 | 20 | 0 | 20 | 40 | 0 | 100 |
| My head of science department provides positive support | n | 3 | 3 | 0 | 1 | 2 | 1 | 10 |
| | % | 30 | 30 | 0 | 10 | 20 | 10 | 100 |
| My head of the science department provides constructive feedback | n | 4 | 2 | 1 | 1 | 1 | 1 | 10 |
| | % | 40 | 20 | 10 | 10 | 10 | 10 | 100 |
| My head of the science department tries hard to figure out how to do things in a proper way | n | 2 | 3 | 4 | 1 | 0 | 0 | 10 |
| | % | 20 | 30 | 40 | 10 | 0 | 0 | 100 |
| The way this school is run makes it easy for science educators to perform their duties | n | 1 | 2 | 2 | 3 | 1 | 1 | 10 |
| | % | 10 | 20 | 20 | 30 | 10 | 10 | 100 |

## 5.3 Data Analysis and Presentation of Questionnaire B.

The statistical information presented in this section is from 250 questionnaires received from FET science learners. Questionnaire B was designed to obtain opinions of FET science learners on what they view as school related factors that contribute towards matriculation failure in science and where necessary, compare them with those expressed by the FET science educators. Besides focusing on the biographical information of FET science learners, the questions in this questionnaire also concentrated on how FET science learners would rate their FET science educators particularly in their teaching methods, time management and general classroom interaction with learners (management skills). All these aspects are very crucial for effective science teaching and learning and usually affect the learner in one way or the other as far as science achievement is concerned.

### 5.3.1 Biographical Information of FET Science Learners.

Although this questionnaire focused on the views and opinions of FET science learners collectively, where it deemed necessary, the results were analyzed and presented separately according to either the grade or gender in order to present the perceptions of learners by grade or gender. This implies that it also highlights and addresses specific learner population, such as gender, that has traditionally been underserved by the education system.

#### *5.3.1.1 Grade category of learners.*

FET level consists of grades 10, 11 and 12. Therefore, it is very important to indicate the number of FET science learners from each grade who participated in this study. Figure 5.22 presents the results regarding the number of FET science learners per each grade who participated in the study.

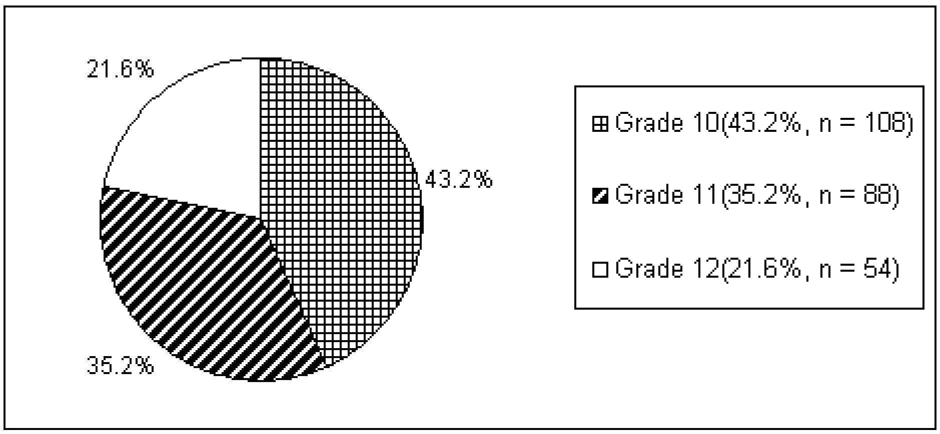


**Figure 5.22: Science learners per grade.**

It is clear that 43.2% (n=108), 35.2% (n=88) and 21.6% (n=54) of the science learners were from grades 10, 11 and 12 respectively (sample selection method 4.3.2).

#### *5.3.1.2 Gender of learners*

Literature has repeatedly shown that science classes are male-dominated (Unisa 2010:1) and therefore this study has attempted to include as many female science learners as possible to bridge the gender gap and obtain more females' views on what could be the factors that lead to high matriculation failure rates in sciences.

Figure 5.23 presents the gender distribution of science learners who participated in the study by grade.

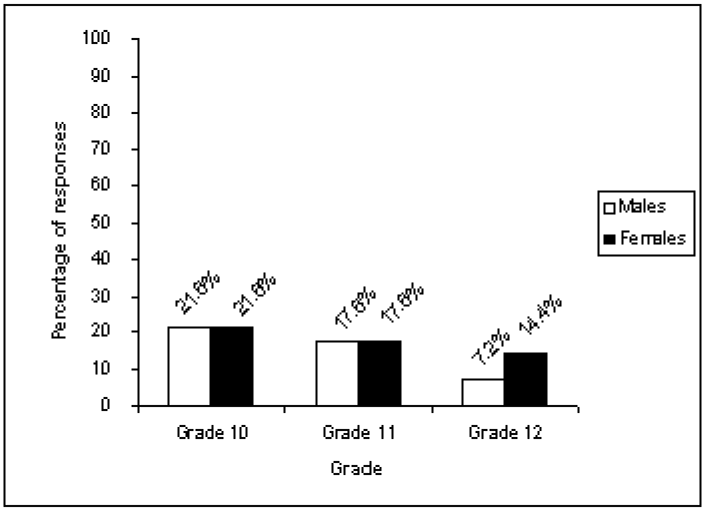


**Figure 5.23: Gender of learners per grade.**

Figure 5.23 shows that an equal distribution of female (21.6%, n=54) and male learners (21.6%, n=54) participated in grade 10. Similarly, a uniformly distributed group of females (17.6%, n=44) and males (17.6%, n=44) also participated in grade 11. However, twice the number of females (14.4%, n=36) as compared to males (7.2%, n=18) participated in grade 12. This implies that a total of 53.6% (n=134) female learners as compared to that one of males (46.4%, n=116) participated in the study.

Such kind of female gender representation that outnumbered the male gender was considered to be fair in this particular study because it catered for the female gender that is usually overlooked and misrepresented in most educational research studies.

### *5.3.1.3 Age category of learners.*

The age of science learners is an important aspect during the interpretation of results. Figure 5.24 presents the age categories of the respondents by their grades.

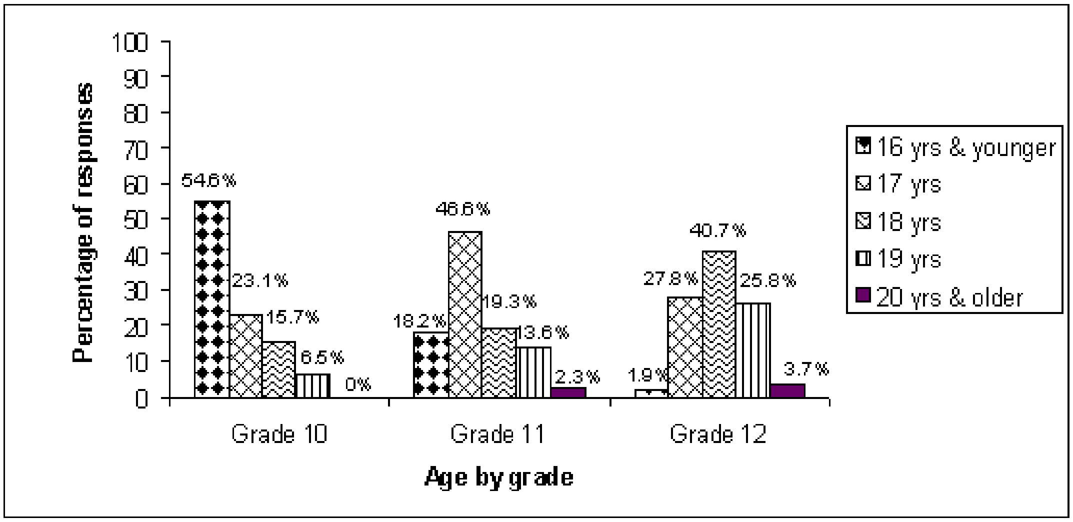


**Figure 5.24: Age category of learners.**

It is clear in figure 5.24 that in grade 10, 54.6% (n=59) were of the age of 16 years and younger, 23.1% (n=25) were of 17 years of age, 15.7% (n=17) were of 18 years of age and 6.5% (n=7) were of 19 years of age. In grade 11, it is revealed that 18.2% (n=16) were of the age 16 years and younger, 46.6% (n=41) were of the age of 17 years, 19.3% (n=17) were of the age of 18 years, 13.6% (n=12) were of the age of 19 years and 2.3% (n=2) were of 20 years and older. In grade 12 only 1.9% (n=1) were of the age of 16 years and younger while 27.8% (n=15) were of 17 years of age. However, a larger number of grade 12 learners (40.7%, n=22) fall within the age group of 18 years, followed by 25.8%

(n=14) who were of the age of 19 years and finally by 3.7% (n=2) of the age of 20 years and older.

The age distributions of the three groups (grades) indicate that some of the learners reach grade 12 as early as the age of 16 years or younger. This may be assumed that such learners' cognitive development may not be ready for abstract conceptualization.

#### *5.3.1.3 Aspect related to number of science learners in possession of a scientific calculator.*

The science curriculum at FET level involves many calculations some of which involve very small numbers and are difficult to solve without a calculator. Therefore a scientific calculator is a prerequisite tool at FET level to make the calculations manageable, easier and faster. Variable number 5 ($V_5$) attempted to find out the number of learners that were in possession of the scientific calculator by grade.

Figure 5.25 indicates the number of respondents with scientific calculators as well as those without. It is rather shocking to note that 28.8% (n=72), 19.2% (n=48) and 10.8% (n=27) of science learners in grades 10, 11 and 12 respectively responded with a *no* to the question: Do you have a scientific calculator?

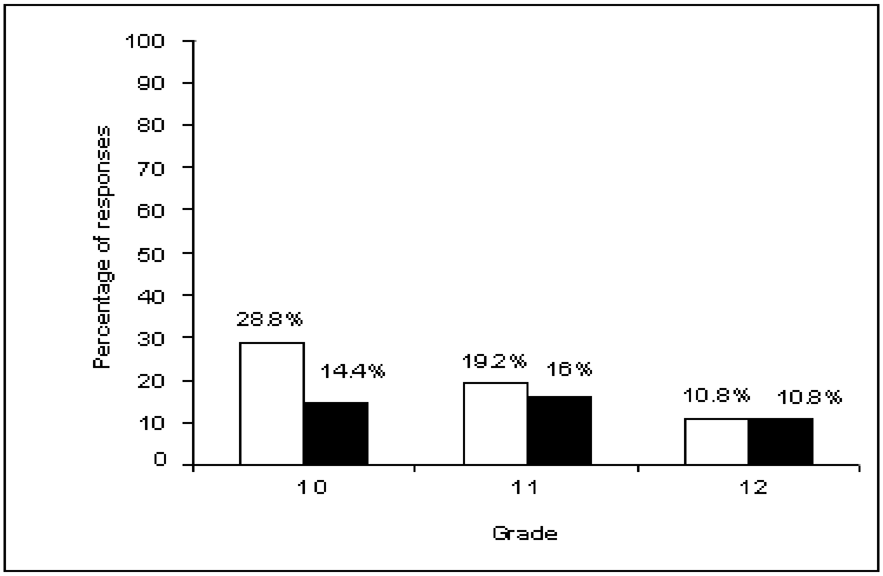


**Figure 5.25: Learners with/without a scientific calculator by grade.**

However, 14.4 % (n=36), 16% (n=40) and 10.8% (n=27) in grades 10, 11 and 12 respectively responded with a *yes* to the same question.

It is therefore disconcerting to note that a total of more than half (58.8%, n=147) of the science learners did not have scientific calculators while less than half the grand total (41.2%, n=103) were in possession of scientific calculators.

***5.3.1.5 Aspect related to absenteeism***

Figure 5.26 shows the number of days the learners had been absent from school by the time the questionnaires were administered in this particular study.

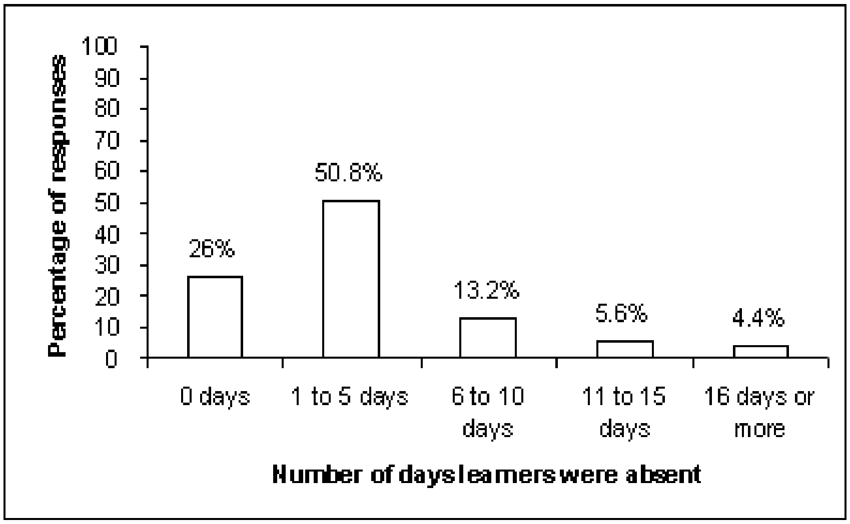


**Figure 5.26: Learners' levels of absenteeism.**

It is encouraging to note that some of the science learners had never been absent from school (26%, n=65).

More than half (50.8%, n=127) had been absent for few days which range between a period of 1 to 5 days. It is a serious concern that 13.2% (n=33) had been absent from school for 6 to 10 days. More disturbing to note is that 5.6% (n=14) had been absent from school for 11 to 15 days while 4.4% (n=11) had been absent from school for 16 days or more.

It may therefore imply that the level of learner absenteeism is very high and as a result negatively affects both the coverage of the syllabus and performance of the learners.

### 5.3.2 Medium of instruction.

Most township schools consist of heterogeneous home- language learners of African indigenous languages. However, in the current South African policy context, English is the common language of instruction and assessment in science.

This section therefore attempted to find out whether learners from Alexandra Township schools are proficient in English and whether their developing English skills provide the medium for engagement with scientific content.

#### *5.3.2.1 Learner's response on aspect related to language of instruction used by the educator.*

Figure 5.27 presents the responses of science learners regarding the language of communication used by their educators during the science lesson. Over half the learners (51.6%, n=127) rated their science educators as using English only as the medium of instruction during the lesson.

This is followed by 46% (n=115) who rated their science educators as using a combination of their (learners') home language and English, 2% (n=5) who rated their science educators as using their own (educator's) home language and English and 0.4% (n=1) who rated their science educators as using their (learners') home language only.

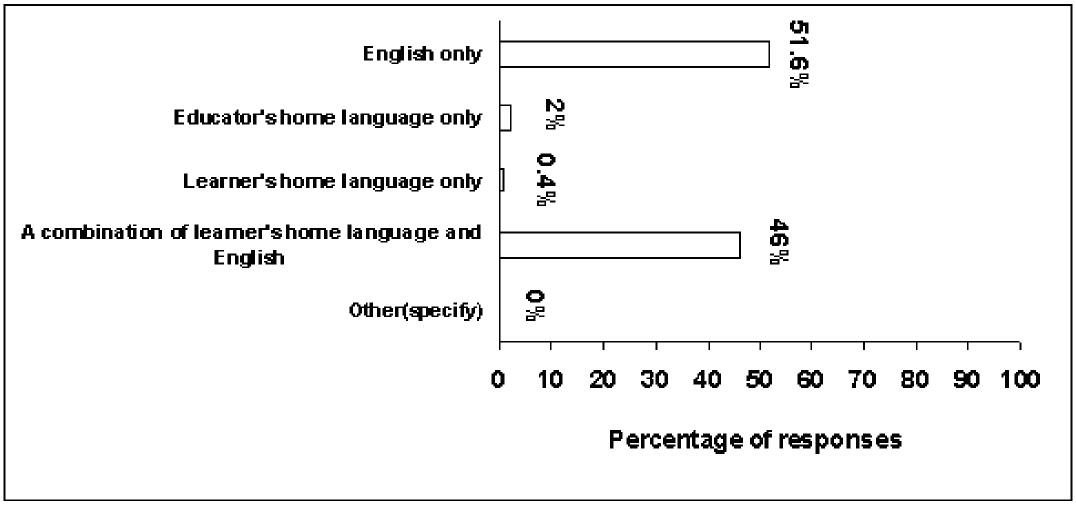


**Figure 5.27: Learners' responses on whether they understand the language of instruction.**

### *5.3.2.2 Aspect related to number of learners who understand the language of instruction.*

Variable 8 ($V_8$) attempted to find out whether science learners understood the medium of communication used by their educators during the science lesson. Figure 5.28 contains responses of science learners to the question: Do you understand the teaching language used by your educator during the science lesson? It is encouraging to note that more than three quarters of the learners (94.8%, n=237) responded with a *yes.* It is however sad to note that some of the learners (5.2%, n=13) responded with a *no*. This may imply that such learners need to develop English language and literacy skills in the context of content area instruction (Needham & Hill 1987: 13).

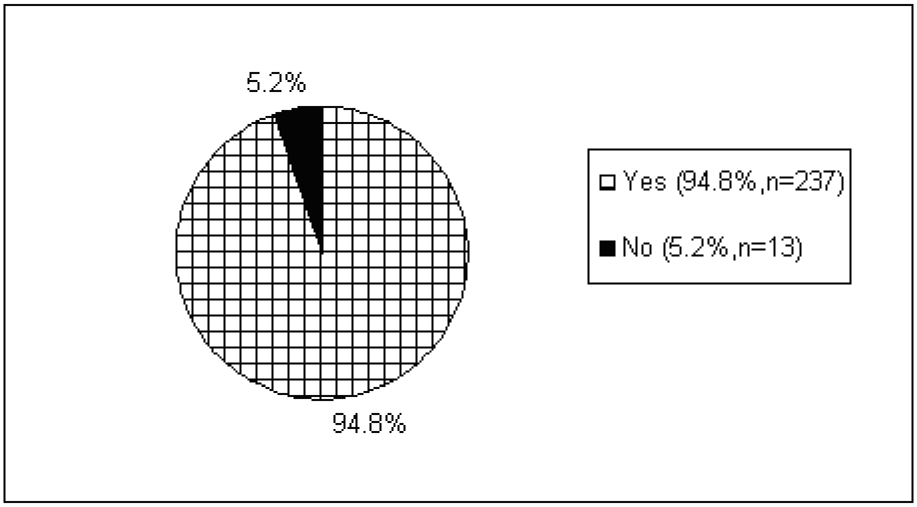


**Figure 5.28: Learners' responses on instructional language of preference.**

Although almost the majority of the learners rated themselves as understanding the language of communication used by their science educators during the lesson, it is however clear from Figure 5.29 that more than half (54.4%, n=134) preferred their science educators to use a combination of English and their (learners') home language ($V_9$). Furthermore, 40.8% (n=102) preferred their science educators to use English only while 4.8% (n=12) preferred their science educators to use their (learners') home language only.

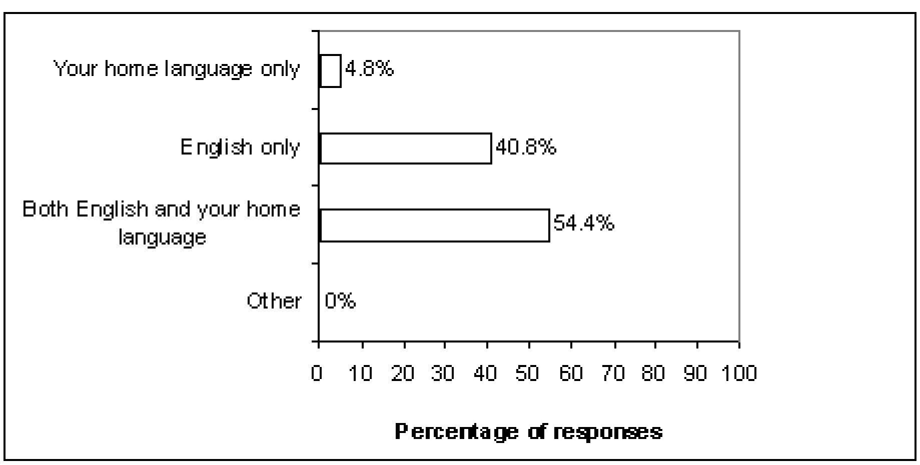


**Figure 5.29: Language of communication preferred by learners.**

***5.3.2.3 Aspect related to linguistic and numerical skills of learners.***

A science learner should have both linguistic and numerical skills. Linguistic skills are very important so that the learner can read the scientific problem with understanding and then express his views in writing using proper English and appropriate scientific terminology in the examination. If the learner cannot read properly or understand what he reads it is therefore impossible for him to solve scientific problems written in English during the examination. Similarly, a science learner should also be numerate. That is, he should have basic skills in mathematics since most of the scientific concepts at FET involve mathematical calculations.

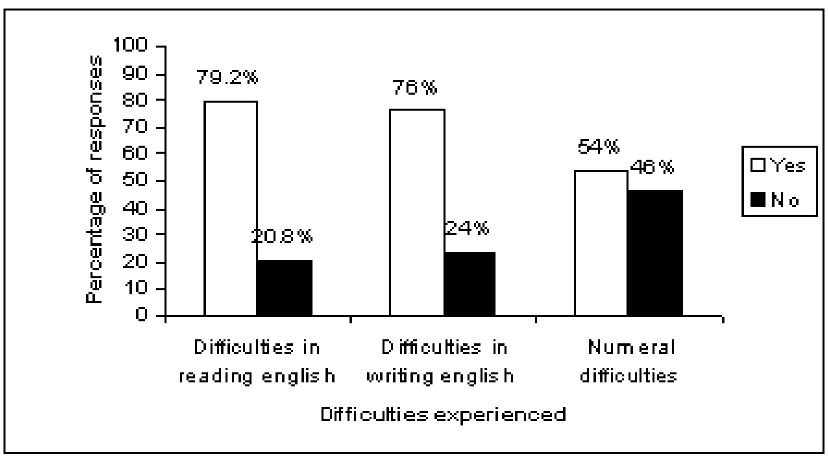


**Figure 5.30: Linguistic and numerical difficulties of learners.**

Responses of science learners related to their linguistic and numerical skills are recorded in figure 5.30. More than three quarters of science learners indicated that they experience no difficulties in reading English (79.2%, n=198) and in writing English (76%, n=190). However the number of learners who indicated that they experienced difficulties in reading English (20.8%, n=52) and in writing English (24%, n=60) is fairly large to result in many learners performing poorly in science. It is also clear that more than half the learners (54%, n=135) rated themselves as having numerical difficulties while 46% (n=115) indicated that they did not have numerical difficulties.

It can therefore be assumed that some learners fail science at matriculation level as a result of experiencing either linguistic or numerical difficulties or both.

### 5.3.3 Learner's response on aspects related to educator's classroom management skills.

Kruger and Steinman (in Deventer & Kruger 2003:15) maintain that a science educator with good classroom management skills uses his knowledge, skills and behavior to create an educator-learner relationship that is characterized by caring, support, openness, listening, critical questioning, and promotion of learner motivation and the will to learn. In other words, the educator should always use his knowledge, skills and behavior to create well-managed environments, which maximize opportunities for the learner to learn, to perform to the best of his ability and to encourage him to continue with confidence in his efforts even if he failed to succeed the first time.

Table 5.10 listed variables that are applicable to some of the classroom management skills the science educator should have. For the sake of discussion, the values attributed to *very poor* and *poor* were grouped together and considered unsatisfactory classroom management skills, while the *good* and *very good* values were noted as satisfactory classroom management skills.

The classroom management skills that were rated by science learners as unsatisfactory obtained the following scores: ability to inspire science learners (52%, n=130), friendliness to science learners (50%, n=125), helpfulness to science learners (43.2%, n=108) and ability to explain clearly during the lesson (30%, n=75).

The ratings for satisfactory classroom management skills were as follows: helpfulness to science learners (48.8%, n=122), ability to explain clearly during the lesson (48%, n=120), friendliness to science learners (46.8%, n=117) and ability to inspire science learners (38%, n=95).

It can also be noted that the ability to explain clearly during the lesson obtained the highest average rating (22%, n=55) while friendliness to science learners obtained the least average rating (3.2%, n=8).

It can be concluded that although some of the science learners rated their educators as satisfactory in other classroom management skills, lack of basic classroom management skills are more dominant and adversely affect teaching and learning of science.

**Table 5.10: Responses of learners' on aspects related to educators' classroom management skills.**

| TRAIT OF THE SCIENCE EDUCATOR | n | Rating of classroom management skills of science educators on scale of 1 to 5 | | | | | Total |
|---|---|---|---|---|---|---|---|
| | % | Very poor | Poor | Average | Good | Very good | |
| Friendliness to science learners | n | 60 | 65 | 8 | 71 | 46 | 250 |
| | % | 24 | 26 | 3.2 | 28.4 | 18.4 | 100 |
| Helpfulness to science learners | n | 75 | 33 | 20 | 65 | 57 | 250 |
| | % | 30 | 13.2 | 8 | 26 | 22.8 | 100 |
| Ability to explain clearly during the lesson | n | 40 | 35 | 55 | 44 | 76 | 250 |
| | % | 16 | 14 | 22 | 17.6 | 30.4 | 100 |
| Ability to inspire science learners | n | 88 | 42 | 25 | 30 | 65 | 250 |
| | % | 35.2 | 16.8 | 10 | 12 | 26 | 100 |

## 6 Opinion survey

This section of the questionnaire attempted to find out the opinions of FET science learners on different variables related to aspects such as effectiveness of the educator's teaching methods, classroom management skills and time management of both educators and learners. The respondents had to indicate the extent to which they agree to the variables listed. For the sake of discussion, the variables in this section were rearranged and divided into respective aspects such as those related to educator's teaching methods (Table 5.11), classroom management skills (Table 5.12) and time management (Table 5.13).

A five Likert rating scale of *strongly disagree*, *disagree, uncertain*, *agree* and *strongly agree* was used to rate each statement. Furthermore, for the sake of discussion, the percentages of negative values (*strongly disagree* and *disagree*) were combined whereas the percentages for positive values (*agree* and *strongly agree*) were also combined.

### ***5.3.4.1 Learners' response on aspects related to educator's teaching methods.***

Responses of science learners on matters related to their educator's teaching methods are recorded in Table 5.11. Over half of the learners agreed or strongly agreed to the following statements: Science has relevance in life (85.6%, n=214), my science educator provides me with useful feedback (67.6%, n=169) and my science educator always gives me homework (58.4%, n=146). It is also clear that two groups of learners which are equally distributed agreed or strongly agreed to the following statements: I experience enjoyment during science lessons (50%, n=125) and science is a theoretical subject (50%, n=125).

However quite a number of the learners strongly disagreed or disagreed with the following statements: We have done many experiments this year in science (82%, n=205), I understand most of the science content we have covered in the lesson (72.8%, n=182), we get opportunity to perform experiments as individuals (72%, n=180), science lessons are interesting enough to keep my attention (59.2%, n=148), we sometimes discover some of the science content on our own as learners (55.6%, n=139) and we get opportunities to perform experiments in groups (52.8%, n=132). Furthermore, equal distributions of negative (strongly disagree or disagree) and positive (agree or strongly agree) responses can be noticed on the following statement: I understand the way my science educator teaches (50%, n=125).

It is important to highlight that some of the learners were *uncertain* to the following statements: We sometimes discover some of the science content on our own as science learners (16%, n=40), I understand most of the science content we have covered in the lessons (8%, n=20), my science educator provides me with useful feedback (6%, n=15), I experience enjoyment during science lessons (4%, n=10) and we have done many experiments this year (4%, n=10). It may be possible to assume that such learners, who responded to their educators' teaching methods with the rating of *uncertain* were also receiving ineffective teaching strategies that could keep their everyday ideas and their school science as separate and distinct (Needham & Hill 1987: 8) whether they should disagree or agree to such teaching methods. This means that the science teaching could not necessarily affect learners' practical knowledge in the long term and hence learners remain unwilling to change the way they see things because of the experiences or teaching methods they were exposed to in their science lessons.

Although some learners indicated that they understood the way their educators taught, Table 5.11 suggests that the majority of learners are not exposed to the new teaching methods that are inquiry based to discover scientific concepts, facts, principles and laws through experimental activities. It may be assumed that educators just give learners symbols to learn but do not provide the necessary experiences to allow conceptualization to occur (Needham & Hill 1987: 5).

As a result, concepts are learnt as names or words rather than as meaningful abstractions by arousing interest through practical activities and reinforce construction of ideas in familiar and novel situations. This ultimately does not allow learners to recognize alternative ideas and critically examine their own, and eventually view science as theoretical, irrelevant and not enjoyable.

**Table 5.11: Extent to which the learner agrees with the educator's teaching methods.**

| STATEMENT RELATED TO THE TEACHING METHOD | n | Rating of teaching methods on a scale 1 to 5 | | | | | Total |
|---|---|---|---|---|---|---|---|
| | % | Strongly disagree | Disagree | Uncertain | Agree | Strongly Agree | |
| I experience enjoyment during science lessons | n | 50 | 65 | 10 | 51 | 74 | 250 |
| | % | 20 | 26 | 4 | 20.4 | 29.6 | 100 |
| Science lessons are interesting enough to keep my attention. | n | 66 | 82 | 3 | 44 | 55 | 250 |
| | % | 26.4 | 32.8 | 1.2 | 17.6 | 22 | 100 |
| We have done many experiments this year in science | n | 111 | 94 | 10 | 9 | 26 | 250 |
| | % | 44.4 | 37.6 | 4 | 3.6 | 10.4 | 100 |
| We get opportunities to perform experiments as individuals | n | 99 | 81 | 0 | 45 | 25 | 250 |
| | % | 39.6 | 32.4 | 0 | 18 | 10 | 100 |
| We get opportunities to perform experiments in groups | n | 63 | 69 | 0 | 38 | 80 | 250 |
| | % | 25.2 | 27.6 | 0 | 15.2 | 32 | 100 |
| We sometimes discover some of the science content on our own as learners | n | 64 | 75 | 40 | 11 | 60 | 250 |
| | % | 25.6 | 30 | 16 | 4.4 | 24 | 100 |
| Science is a theoretical subject | n | 49 | 72 | 4 | 16 | 109 | 250 |
| | % | 19.6 | 28.8 | 1.6 | 6.4 | 43.6 | 100 |
| Science has relevance in life | n | 12 | 24 | 0 | 113 | 101 | 250 |
| | % | 4.8 | 9.6 | 0 | 45.2 | 40.4 | 100 |
| I understand most of the science content we have covered in the lesson | n | 104 | 78 | 20 | 25 | 23 | 250 |
| | % | 41.6 | 31.2 | 8 | 10 | 9.2 | 100 |
| My science educator always gives me homework | n | 21 | 83 | 0 | 77 | 69 | 250 |
| | % | 8.4 | 33.2 | 0 | 30.8 | 27.6 | 100 |
| My science educator provides me with useful feedback | n | 25 | 41 | 15 | 78 | 91 | 250 |
| | % | 10 | 16.4 | 6 | 31.2 | 36.4 | 100 |
| I understand the way my science educator teaches | n | 62 | 63 | 0 | 57 | 68 | 250 |
| | % | 24.8 | 25.2 | 0 | 22.8 | 27.2 | 100 |

#### *5.3.4.2 Learner's response on aspects related to the educator's classroom management skills.*

The quality and frequency of interaction in the classroom depends on the educator's classroom management skills. As a follow up to $V_{13}$, $V_{14}$, $V_{15}$ and $V_{16}$, Table 5.12 presents responses of learners on the extent to which they agree to their science educators' classroom management skills.

Over half of the learners agreed or strongly agreed with the following statements: My science educator inspires me to do my best all the time (72.8%, n=182), I have the courage to ask questions during the science lessons (64%, n=160) and I am confident that I will pass science in my exams (61.6%, n=154). It is also clear that more than half of the learners responded to the statement listed in table 5.12 by either strongly disagreeing or agreeing that: My science educator treats all learners fairly in my class (74.4%, n=186), My science educator cares whether I understand (56%, n=140) and, My science educator provides support to me in class to deal with problems (51.2%, n=128). In addition, closer to half the learners also responded by either strongly disagreeing or disagreeing to the following statements: my science educator always explains everything clearly (48.8%, n=122) and, I have confidence to openly express my ideas during the science lessons (46.8%, n=117). These negative responses (strongly disagree or disagree) are in consistent with unsatisfactory responses (very poor and poor) provided in Table 5.10 on related aspects of classroom management skills.

**Table 5.12: Extent to which the learners agree with the educator's classroom management skills.**

| STATEMENT RELATED TO CLASSROOM MANAGEMENT SKILLS | n | Rating of classroom management skills on scale of 1 to 5 | | | | | Total |
|---|---|---|---|---|---|---|---|
| | % | Strongly disagree | Disagree | Uncertain | Agree | Strongly agree | |
| My science educator inspires me to do my best all the time | n | 26 | 34 | 8 | 72 | 110 | 250 |
| | % | 10.4 | 13.6 | 3.2 | 28.8 | 44 | 100 |
| My science educator cares whether I understand | n | 93 | 47 | 2 | 21 | 87 | 250 |
| | % | 37.2 | 18.8 | 0.8 | 8.4 | 34.8 | 100 |
| My science educator always explains everything clearly | n | 45 | 77 | 7 | 33 | 88 | 250 |
| | % | 18 | 30.8 | 2.8 | 13.2 | 33.2 | 100 |
| I am confident that I will pass science in my exams | n | 21 | 36 | 39 | 70 | 84 | 250 |
| | % | 8.4 | 14.4 | 15.6 | 28 | 33.6 | 100 |
| I have confidence to openly express my ideas during the science lessons | n | 57 | 60 | 16 | 36 | 81 | 250 |
| | % | 22.8 | 24 | 6.4 | 14.4 | 32.4 | 100 |
| I have courage to ask questions during science lessons | n | 37 | 44 | 9 | 55 | 105 | 250 |
| | % | 14.8 | 17.6 | 3.6 | 22 | 42 | 100 |
| My science educator treats all learners fairly in my class | n | 83 | 103 | 12 | 11 | 41 | 250 |
| | % | 33.2 | 41.2 | 4.8 | 4.4 | 16.4 | 100 |
| My science educator provides support to me in class to deal with problems | n | 44 | 84 | 2 | 67 | 53 | 250 |
| | % | 17.6 | 33.6 | 0.8 | 26.8 | 21.2 | 100 |

#### *5.3.4.3 Learners' responses on aspects related to time management.*

Table 5.13 presents responses of learners with regard to time management by both science educators and learners. It can be noted from Table 5.13 that more than half of the learners responded by agreeing or strongly agreeing to the following statement: I always do science homework in time (67.6%, n=169) while almost half of the learners (49.6%, n=124) were also in agreement (agreed or strongly agreed) with the following statement: I am always on time for the science lesson.

However, it is disconcerting to note that quite a number of learners either strongly disagree or disagree to the following statements: my science educator is always on time for science lessons (74.8%, n=187), my science educator uses enough time for each topic (65.6%, n=164), after homework my science educator immediately marks my work (52.4%, n=131) and, I am always on time for the science lessons (51.9%, n=129).

Further analysis of Table 5.13 shows that very few learners were uncertain to the following statements: My science educator uses enough time for each topic (2.4%, n=6) and that, after homework my science educator immediately marks my work (1.6%, n=4).

**Table 5.13: Extent to which learners agree to the aspects related to time management.**

| STATEMENT RELATED TO TIME MANAGEMENT | n | Rating of time management on a scale of 1 to 5 | | | | | Total |
|---|---|---|---|---|---|---|---|
| | % | Strongly Disagree | Disagree | Uncertain | Agree | Strongly agree | |
| My science educator uses enough time for each topic | n | 89 | 75 | 6 | 30 | 50 | 250 |
| | % | 35.6 | 30 | 2.4 | 12 | 20 | 100 |
| My science educator is always on time for the science lesson | n | 79 | 108 | 0 | 13 | 50 | 250 |
| | % | 31.6 | 43.2 | 0 | 5.2 | 20 | 100 |
| I am always on time for the science lesson | n | 66 | 63 | 0 | 60 | 64 | 250 |
| | % | 26.4 | 25.5 | 0 | 24 | 25.6 | 100 |
| I always do my homework in time | n | 33 | 48 | 0 | 66 | 103 | 250 |
| | % | 13.2 | 19.2 | 0 | 26.4 | 41.2 | 100 |
| After homework my science educator immediately marks my work. | n | 55 | 76 | 4 | 59 | 56 | 250 |
| | % | 22 | 30.4 | 1.6 | 23.6 | 22.4 | 100 |

## 5.4 Summary

In this chapter, results acquired from questionnaire A and questionnaire B were classified, analyzed, interpreted and discussed. Generally, the results were defined more clearly by classifying various aspects in terms of those related to educators' teaching experience, qualifications, knowledge of subject content, teaching methods, medium of instruction, workload, classroom management skills, morale and motivation. In addition, results were also grouped in terms of aspects related to class size, availability of resources, time management, and levels of absenteeism and management skills of the heads of science department. This made analysis and interpretation of data easier.

If the opinions and views expressed by educators are taken together, it appears that the majority of educators has less experience of teaching science at FET (60%), posses a teaching diploma or other qualification (60%) and teaches large classes (90%). With regard to the content of the subject, a total of 70% of science educators indicated that they found mathematical part of science to be difficult while a total of 50% showed that both chemistry and physics were difficult to teach.

It is interesting to note that some of the opinions and views of both educators and learners correspond to a large extent with regard to the teaching methods. In the light of the percentages of learners on this regard, a total of 50% indicated that they did not understand the way their educators teach science ($V_{40}$). Seen as a whole, this could possibly be linked to the analysis of data obtained that shows much smaller percentages of educators who rated themselves as using a variety (20%) of teaching methods ($V_{38}$).

While there is a general feeling by some educators (40%) that heads of science department in schools do not provide them with necessary support for effective teaching, a bigger percentage of learners (51.2%) on the other hand also feel that their educators do not care and provide them with the necessary support for effective learning.

Although it is noticeable that both educators and learners scored very high regarding their levels of absenteeism, it appears from the investigation that the largest percentage was recorded among learners (76.8%) than educators (60%).

Further analysis of the data revealed that the majority of educators (90%) were not satisfied with their salaries ($V_{86}$). It is possible to suggest that such educators have low morale and very low levels of motivation and as a result, this negatively affects the effectiveness of teaching and learning.

It is nevertheless clear that data analysis from Chapter 5 established broad possible factors related to the school that are associated with relatively high matriculation failure rates in science.

From this information, conclusions and recommendations were formulated as presented in the next chapter.

# CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

## 6.1 Introduction

This chapter contains conclusions, recommendations and limitations to the study. It was established from the literature that the economic prosperity of a country is closely linked to the level and rate of its technological development which in turn is heavily dependent on the skills of a pool of adequate scientists, technicians and technologists of the nation as a whole (South Africa 2003:9, South Africa 2008: 8-9). It therefore means that there should be a reason for concern if it becomes evident that the number of learners passing science at matriculation level is dismally decreasing since that is an entry point for such scientific oriented professions.

The study originated from the evidence and recognition that underachievement in science at matriculation level, particularly, in historically disadvantaged township public high schools of South Africa, is nose-diving yearly and has resulted in massive shortages of scientific workforce in all sectors (South Africa 2008: 9). Literature further established that this has become a major concern for the whole nation such that South Africa has started hiring foreign scientific workforce, including science educators to cater for the critical scientific skill shortages (South Africa 2008: 12). It is against this background that the study was undertaken to identify and analyze the school related factors that contribute towards high matriculation failure rates in science in public high schools of Alexandra Township. The second objective was to suggest strategies for monitoring and improving performance of both science educators and learners and ultimately increase the science matriculation pass rate.

The study relied basically on the input-process-output (outcome) model (Howe 2003:4) which shows that the output (outcome) or learner achievement is affected by both the input and the process factors within the school as an organization.

## 6.2 Conclusions.

This section presents the conclusions obtained from the study. It summarizes major research findings as they appear in data analysis and presentation of both questionnaires in chapter 5 since the main purpose of the two questionnaires was to gather views and opinions of science educators and learners on school related factors that cause high matriculation failure rates in science. Furthermore, the study relates the research findings to previous studies obtained from the literature review and justifications of this study.

It is important to highlight that some of the research findings in this study replicate results of previous studies done elsewhere in South Africa. However it is also crucial to realize that this study extends those findings to FET science teaching and learning in Alexandra, the northern Township of Johannesburg.

### 6.2.1 Research Findings.

Overall, the study results suggest that the school related factors that negatively affect learner achievement in science are many. Therefore, educational administrators should effect change. Furthermore, data obtained in chapter 5, reveals that the school related factors that causes high matriculation failure rates in science are multifarious and interlinked in such a way that they create a chain of critical and pervasive problems some of which are discussed below.

#### *6.2.1.1 Lack of properly qualified science educators.*

The fact that some educators had studied science at standard grade at high school (Figure 5.4) and that some trained in science and another subject other than mathematics during teacher training course (Figure 5.6) indicates that these educators were not well groomed in science and are also not science experts as compared to science educators who would have passed science at higher grade or "A" level Cambridge and majored in science alone as a subject during the teacher training course. Thus the quality of science educators produced in South Africa may be considered deficiency in science conceptual understanding and practical skills which were not provided at standard grade or during the teacher training course when they had too many subjects to study than when one had majored in science alone to become the subject specialist.

#### *6.2.1.2 Lack of subject content.*

Science educators at FET level should have entire knowledge of chemistry, physics and mathematics. The fact that some science educators indicated that both physics and chemistry were difficult to teach, that either chemistry or physics was difficult to teach (Figure 5.8) and that mathematics was also difficult to teach (Figure 5.9) makes it possible to conclude that such educators are deficient in declarative knowledge(subject content). Lack of procedural knowledge, particularly in terms of steps, methods, strategies, processes to follow (Tables 5.4, 5.7 and 5.11) and specific skills to use such as organizational skills (Table 5.5) and classroom management skills (Tables 5.6, 5.10 and 5.12) were also established. Table 5.3 generally showed lack of both declarative and procedural knowledge. Literature has already established that an educator cannot expose the learners to the content, cannot be thorough in coverage of the topics and cannot also make connections between the topics if he lacks the subject matter (declarative knowledge) and classroom management skills (procedural knowledge) (Prince & Nelson 2007: 4).

The purpose of the science educator in class is to simplify the subject matter so that it can be accessible to learners (Halloun 2006:12, Trowbridge et al 2004:213). The perceived deficiency in both declarative knowledge and procedural knowledge in this study therefore makes it possible to conclude that an educator cannot simplify and teach the learner what he does not understand himself. Subsequently, this hampers the unfolding of knowledge, the transfer of skills and attitudes and the provision of feedback to learners (Tables 5.9, 5.11 and 5.13). As a result, this does not build interest in the subject (Figure 5.17) and hence contribute to underachievement in science at matriculation level.

#### *6.2.1.3 Lack of science resources.*

In addition, the research study has also shown that schools in Alexandra Township are under-resourced in terms of facilities such as laboratories (Figure 5.7), chairs, tables, science chemicals, science equipment and a variety of learner-educator support materials for learners to do self-discovery and practical work (Tables 5.2, 5.7, and 5.11). Lack of these important resources has a negative impact on learner achievement in science (Legotlo et al 2002: 115, Howe 2003:2).

Furthermore, literature by Trowbridge et al (2004: 182-183) has revealed that availability of resources encourages and motivates educators to do practical work. This in turn enhances learners' interest in science, increases their manipulative skills and memory of content, makes the subject relevant, helps them to acquire skills and ideas of discovery, promotes discipline and helps them to solve problems. However, this study revealed that little attention is given to practical work (Tables 5.7 and 5.11). Although this can be mainly attributed to insufficient material resources there can be other possible reasons attached to this which may include:

- Lack of time since many science educators indicated that they teach only for examinations purposes (Table 5.7). Therefore it can be possible to conclude that educators lay more emphasis on those aspects of the science curriculum which can be tested at matriculation level and hence leave practical work since it is both not examinable and time consuming that educators may not finish the syllabus during the allocated time.

- Large numbers of learners in class (Figure 5.10) make practical work more difficult to conduct and supervise since control and discipline may be affected adversely.
- With the poor quality of science educators as indicated in subsection 6.2.1.1 above, it may also be possible to conclude that these educators lack both practical skills and knowledge of how to use certain equipment and therefore choose to avoid practical work completely.

Although the new curriculum emphasizes more on practical work requiring learners to do observations through experiments and extend their scientific boundaries and enable them to use and apply scientific skills (South Africa 2003:10, South Africa 2008:2), this study however reveals that schools in this particular Township are under- resourced for educators and learners to perform certain experiments.

Another blow is lack of scientific calculators by learners (Figure 5.25) which makes it difficult for learners to do certain mathematical calculations in science.

#### *6.2.1.4 Overburdened science educators*

The quality of teaching is perhaps the most important factor that influences achievement in science (Fonseca and Conboy 2006:92). It can be accepted from the data analysis that the science educators in public high schools of Alexandra Township are overburdened (overloaded) with work to such an extent that their quality of teaching inevitably deteriorate.

Some of the common factors that lead to overburdening of science educators that were identified in this study include different and unrelated subjects taught by one educator, large science classes, too many periods per week to teach and unnecessary OBE paper work.

#### *6.2.1.4.1 Too many subjects to teach*

Figure 5.10 shows that some science educators taught more than one subject. As a result, they have more than one different syllabus to study, more than one different lesson plans to prepare and more question papers to set which also result in the drawing up of more memoranda for internal examinations. At the same time this implies that they have more work to mark.

Such overburdening reduces the effectiveness and efficiency of science educators and eventually affects the learner who is at the centre of the learning experience.

#### *6.2.1.4.2 Large science classes*

Large numbers of learners in science classes are common and seem to be another major stumbling block to science achievement in public high schools of Alexandra Township as most educators in this study indicated that they teach 46 or more learners in their classes (Figure 5.11).

In such large classes, the wide range of actions which have to be taken into account such as individual practical work, preparation of equipment, the marking of the learners' work, lots of correctional work, individual assistance to learners and interactions between learners hamper effective teaching and learning of science (Needham & Hill 1987:26-31). This is evident in Figure 5.12 where most educators indicated that they could not cope teaching such large classes.

One may argue that in such large classes the educator may use worksheets but one may not assume that all learners read well enough as Figure 5.30 of questionnaire B shows that 79.2% of science learners are not proficient in reading English.

In addition, the writing of worksheets needs skill and in particular takes an almost disproportionate amount of time (Needham & Hill 1987: 26) which together with huge and unnecessary administrative paper work from OBE curriculum (Table 5.8) causes problems in respect of the overburdening of science educators.

*6.2.1.4.3 Too many periods per week*

Figure 5.13 reveals that a cumulative percentage of 90% (n=9) of science educators taught 31 lessons or more per week. This implies that they are left with fewer or no free periods to do administrative duties and other activities such as marking the learner's work, follow up work, prepare or change apparatus and aids they use. This could also be the reason why most educators indicated that they could not cope with their teaching load (Figure 5.14).

#### *6.2.1.5 Poor classroom management skills*

This study has revealed that deficiencies in classroom management skills are common among science educators (Tables 5.6, 5.10 and 5.12). Shindler (2010:364) and Ruby (2006:1006-1007) ague that good classroom management skills are very important and assist in maintaining discipline during the lesson and also increases the learner's appetite to learn, willingness to take risks, step outside the defined boundaries and hence be accountable for his own learning.

#### *6.2.1.6 Outdated teaching methods.*

It appears that the teaching methods applied by most science educators do not allow learners to take ownership from the educators (Table 5.4), reduces teaching to exam spotting and train learners to do well in exams only (Table 5.7), rather than develop scientific knowledge and skills through both minds-on and hands-on activities (South Africa 2008:4). Lack of opportunities for learners to explore ideas through experiments (Table 5.7 and 5.11) implies that science teaching in these schools still encourages parrot learning (South Africa 2008:2).

Literature has already revealed that human knowledge about physical realities is a mix of both experiential and traded knowledge (Halloun 2006:11-12). In this regard, it is further argued that experiential knowledge promotes learners to develop knowledge through direct transaction with the physical realities and empirical data while traded knowledge allows learners to obtain knowledge from educators, peers and textbooks. However this study found that most of the science learners were not stimulated and encouraged by the methods of teaching because some educators took them as passive recipients (Table 5.11).

#### *6.2.1.7 Dysfunctional science departments in schools.*

This study found that some science departments in schools are dysfunctional due to the heads of science that lack managerial skills (Table 5.6 & 5.9). These results clearly indicate that some heads of science department in schools are not involved in interactive and interrelated processes of managing human resources (educators and learners) as well as physical resources (laboratories and equipment) as effectively as possible to achieve the outcomes of effective teaching and learning.

Most importantly, the findings show that most heads of science department lack team building skills (Table 5.9) which in this study is considered to be very crucial for both educators and learners in the concepts of involvement, decision making, ownership, commitment, responsibility and creation of a positive school climate. Deventer and Kruger (2003:17) view a positive school climate as the quality and frequency of interactions in which both educators and learners are assisted by their heads of department along a number of developmental pathways for effective teaching and learning. However the findings reveal that lack of professional development of science educators, lack of support for both science educators and learners and lack of communication within the science department are dominant factors in schools (Table 5.9).

In addition, poor management skills by science heads, particularly related to planning are manifested in situations where some science educators are allocated more than one learning area or allocated the learning area(s) they had not trained for at the teacher training college (Figure 5.10).

While previous research has already shown a strong correlation between good management skills by the science head and student achievement (Shindler 2010: 363), the findings in this study takes a step further by revealing that taking responsibility and accountability by heads of science are most valuable experiences for effective teaching and learning. Van der Mwere (in Deventer & Kruger 2003:45) argues that the head of department with good management skills posses a distinct mix of knowledge, skills, personal attitudes and values, and always produces positive outcomes.

#### *6.2.1.8 Lack of motivation and perseverance.*

Both sub-samples expressed lack of motivation and perseverance with no significant differences between educators and learners for engaging in science teaching and learning. The fact that most science educators were not satisfied with their salaries and that some of the hardworking science educators were not recognized in their schools (Table 5.8) together with deficiencies of resources in schools (Table 5.2) may lead one to assume that science educators are left with very low levels of morale in such a way that their quality of teaching is affected. Such lack of motivation in science educators may even explain further why some educators did not do remedial teaching or offered expanded opportunities to learners at their own initiative (Table 5.4) and most importantly why they did not care whether learners understood during the lesson (Table 5.12).

It is therefore logical to argue that if the educator is not motivated, the learner may also not be motivated such that he may end up not enjoying the science lessons (Table 5.11) and hence have a negative attitude towards the subject (figure 5.17).

#### ***6.2.1.9 Communication barriers.***

This study has revealed that most learners lack both mathematical and linguistic skills (Figure 5.30) which are important for communicating scientific concepts. It may be assumed that using English as the language of instruction and assessment (Figure 5.27) seems to make science learning a big challenge for township learners who speak African indigenous languages as their home language. This implies that besides learning the subject (science) content, the learners in township schools are also trying to learn English, which is the language of instruction and assessment as well as mathematics, which is used for communicating scientific concepts.

This study found that the difficulty of not able to understand and communicate fluently in English (Figure 5.30), a common language which is used as the medium of instruction and assessment were far from optimal and covered a broad spectrum. This could possibly be attributed to the fact that Township schools have increasingly larger numbers of science learners in class from diverse cultural and linguistic backgrounds or due to the apartheid legacy where African learners (black learners) are taught by African educators (black educators) who are also not English experts. This, together with the fact that some science learners indicated that they had some numerical difficulties (Figure 5.30) while others also indicated that they preferred to be taught in their home language (Figure 5.29) may be assumed as a possible communication barrier in science lessons that could lead to matriculation failure rates since science is communicated both linguistically and mathematically.

#### *6.2.1.10 Absenteeism*

The study has also shown that high levels of absenteeism (Figure 5.21 and 5.26) is a common factor to both educators and learners and causes significant reduction in teaching time. Further reduction of teaching time, in terms of time allocated for the period occurs during the change of the lesson as learners take more time than necessary to go to the next lesson (Figure 5.19).

## 6.3 Limitations of the study.

Despite the number of FET science learners in this study being relatively large (n=250), the findings may be limited due to a relatively small number of FET science educators (n=10) from a small sample of two public high schools.

Furthermore, the huge difference between the two sub-samples, of respondents made it impossible and not useful for comparison of data for every variable though comparison of data between the two sub-samples was initially considered to distil more lucrative results.

Another limitation of this study is related to the design of both questionnaires since there was no provision for open ended questions to reveal information not tapped by all the closed questions. This may imply that some valuable information never surfaced from this study since closed questions did not allow for a greater depth of response.

Although all school related factors that causes high matriculation failure rates in science may not have been dealt with during this study, it is hoped that the data from the literature review, research methods, research instruments and results of this study may serve as the foundation for further research that may address aspects that may have been overlooked during the study.

## 6.4 Recommendations from the study.

Evidence from this study reveals that school related factors that cause high matriculation failure rates in science are multifarious. Therefore, broad areas of recommendations to be addressed, together with possible strategies that may be implemented are provided in this section.

- The Department of Education should separate the two components of science at FET namely physics and chemistry so that each gets normal periods per week like any other full-school subject. This as a result, provides more time for educators to do practical work, emphasize the relationship between each subject (component) in daily-situations and make each subject less abstract, less theoretical, less difficult and more relevant. This develops learner's skills and attitudes that are necessary for scientific skills rather than race over the syllabus for examination purposes.

- The Department of Education should have stringent criteria of recruiting better qualified science educators with at least an Honours degree or equivalent qualification in science because such educators are specialists with both in-depth knowledge of the subject content and pedagogical content.

- In addition, the Department of Education should build knowledge and develop competencies by intensifying, strengthening and enhancing workshops, in-service training programs and professional development programs that are rigorous and related to both pedagogical content and content of the subject knowledge. Such programs should be compulsory to all science educators and heads of science. Heads of science department should attend separate workshops on management and leadership skills so that they are able to provide support to their educators and learners as well as create a culture of hard work. In addition, such programmes should also aim at improving both content knowledge and pedagogical knowledge of the head of science so that they know what, when and how to assess and evaluate. This will ultimately create educators' capacity, effectiveness, efficiency, skills and competencies in teaching science, and by extension, improve learner achievement and understanding of science.

- Learners should be encouraged to do science as early as primary school level in order to motivate them towards the subject and to catch talent at a young age and nature it. This together with an increased awareness of science and technology and the essential role they play to the nation through the media may motivate and encourage learners to have tenacity and persistence and hence build positive attitude towards science. Related to this, FET science educators should quickly identify both the learner's attitude towards science and their weak areas early in grade 10 as they come from grade 9 at the beginning of the year and try to give extra attention and support till learners write final exams in grade 12.

- Getting the basics right such as punctuality for lessons by both science educators and learners, avoid unnecessary absenteeism from school by both science educators and learners, educators and learners who are ready to work from day one, and learners who are equipped with all the necessary textbooks and stationary such as scientific calculators. All this can be achieved through proper supervision and monitoring by the school heads and through support from the Department of Education.

## 6.5 Concluding Remarks

This section presents the concluding remarks. The study has found that high levels of absenteeism, late arrival for lessons, poor time management, lack of motivation and lack of commitment and perseverance were pervasive and common factors among both educators and learners, and adversely affect the teaching and learning of science in Alexandra Township public high schools.

In addition, factors that were found to be most prevalent in educators such as poor teaching methods, lack of the subject content, lack of classroom management skills and overburdening could not create enthusiasm and interest in learners. As a result learners could not see the relationship between the subject matter and the everyday world, and hence developed negative attitude towards the subject which led to underachievement in science.

Furthermore, lack of resources such as laboratories and apparatus for performing crucial science experiments was found to be dominant in schools while on the other hand shortage of resources such as scientific calculators was common among learners.

It was also established that learners were at a loss regarding basic mathematical and linguistic skills that are normally used in explaining scientific concepts and this was believed to lead to communication barriers. Documentary analysis, found that overburdening resulted in educators setting questions in class exercises and tests with fewer marks and which did not demonstrate in-depth knowledge of scientific processes. The fewer short questions permitted a merely superficial coverage of topics and did not probe learners' ability to articulate their answers in a written form. Hence opportunities to test ability to synthesize information from different topics are limited.

From the literature review the study found that Alexandra Township is of the lowest socioeconomic status with the highest illiterate rate in Gauteng Province. Although this was not the focus of the study, this did seem to the researcher that it could have an effort revealing such findings for further research in order to find out whether poor socioeconomic conditions, level of parental education, together with the school related factors from this study, collectively contribute towards underachievement of science learners in this particular Township.

Literature review also established that there is a growing interest by various researchers on why learners are performing poorly in science in various parts of South Africa in an effort to better understand on how to improve the teaching and learning of science. However most of the previous research studies focused at the causes of poor performance in science at lower grades, while those which concentrated at higher grades used samples of schools from other parts of South Africa such as rural areas. None of such studies have been conducted using public high schools in Alexandra

Township. Therefore conducting this study in public high schools of Alexandra Township has bridged some empirical gaps.

Although participants used in this study were from a sample of two public high schools, the conclusion drawn can be suffused to FET science educators and learners in other high schools of Alexandra Township and the rest of the public high schools in other townships of South Africa with schools that share similar demographic structures, organizational structures and socioeconomic status.

## 6.6 Suggestions for further research.

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This section consists of suggestions for further research. Based on the limitations of this study, it may be suggested that further research should:

- Investigate the school related factors that cause high matriculation failure rates in science in Alexandra Township using a larger sample of schools and respondents (especially larger sample of FET science educators),
- Investigate the causes of high matriculation failure rates in science in Alexandra Township by considering socioeconomic status, home based, parental level of education and school based factors

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***Appendix 1***

Patson Muzah
C/o Dr Nkopodi
UNISA
College Of Human Sciences
Dept.Of Educational Studies
**PRETORIA 0003**

17 August 2009

The District Director
Department Of Education
142 – 144, 4th Street
**Parkmore**

Dear Sir/Madam

**RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH IN PUBLIC HIGH SCHOOLS OF ALEXANDRA TOWNSHIP IN FULFILLMENT OF THE REQUIREMENTS FOR A MASTERS DEGREE OF EDUCATION IN NATURAL SCIENCES STUDIES WITH UNISA**

I am a Physical Science and Technology Educator at Tharabollo secondary school in Palm Springs, in Gauteng Province. I am currently enrolled as a Masters of Education (Natural Science) student under the supervision of Dr. Nkopodi in the Department of Educational Studies at Unisa.

As part of my studies I am required to undertake research in fulfillment of the requirements for attaining my degree. The title of my research is; **"An exploration into the school related factors that causes high matriculation failure rates in physical sciences in public high schools of Alexandra Township."**

The purpose of the study is to investigate and analyze the school related factors that cause high failure rates in science at matriculation level in public high schools of Alexandra Township in order to suggest ways of improving the teaching and learning of sciences. I believe this will in turn increase the pass rate in this learning area.

To complete this research, physical science educators and grade 10, 11 and 12 science learners in public high schools of Alexandra Township need to complete the questionnaire and be interviewed in certain circumstances. I therefore request your permission to undertake this research at public high schools in Alexandra.

Participation by respondents will be voluntary. Anonymity and confidentiality will be assured to all participants. Furthermore, the research processes will not disrupt any lessons or any scheduled activities at the schools that will participate in this exercise.

Enclosed, please find copies of the draft questionnaires to be used for the research project. The documents are submitted for your perusal and approval to undertake the research studies. A written approval to be used as a letter of introduction to the targeted schools would be appreciated.

Thanking you in advance for your assistance.

Yours Faithfully

Patson Muzah
UNISA STUDENT ID 41492919
Mobile: 072 434 8800
Email address: patsonmuzah@yahoo.com

*Appendix 2*

| | | | |
|---|---|---|---|
| | | | $V_1$ |

No

# QUESTIONNAIRE FOR GRADE 10, 11 AND 12 SCIENCE EDUCATORS

**INSTRUCTIONS**

a) Please give your response to each of the following questions.

b) At each question read all answers first and indicate your answer by placing an X in one box only.

c) Answer all questions.

d) Your responses are confidential and no one in the school will see the answers you give, therefore be honest.

**SECTION 1: BIOGRAPHICAL VARIABLES**

1. What is your gender?

| | | |
|---|---|---|
| Male | 1 | $V_2$ |
| Female | 2 | |

2. What are your overall years of teaching experience?

| | | |
|---|---|---|
| 0 to 5 years | 1 | |
| 6 to 10 years | 2 | $V_3$ |
| 11 to 15 years | 3 | |
| 16 years or more | 4 | |

3. Please indicate years of experience in the teaching of science at FET (Grades 10,11and 12)

| | | |
|---|---|---|
| 0 to 5 years | 1 | |
| 6 to 10 years | 2 | $V_4$ |
| 11 to 15 years | 3 | |
| 16 years or more | 4 | |

4. Please indicate the highest qualification you obtained in science at high school.

| | | |
|---|---|---|
| Grade 12 Science at Standard Grade | 1 | |
| Grade 12 Science at Higher Grade | 2 | |
| GCEôOô Level Cambridge Science | 3 | $V_5$ |
| GCEôAô Level Cambridge Science | 4 | |
| Did not do Science at High School | 5 | |
| Other (Please specifyé é é é é é é é é é é é é é é ) | 6 | |

5. Are you a qualified science educator?

| | | |
|---|---|---|
| Yes | 1 | $V_6$ |
| No | 2 | |

6. What is your highest qualification in teaching?

| | | |
|---|---|---|
| Teacherôs certificate (Certificate in Education) | 1 | |
| Teaching Diploma (Diploma in Education) | 2 | |
| Bachelor of Education Degree | 3 | |
| Advanced Certificate in Education | 4 | |
| Post Graduate Certificate in Education | 5 | $V_7$ |
| Honours Bachelor of Education Degree | 6 | |
| Masters in Education | 7 | |
| Doctorate in Education | 8 | |
| Other (Please specifyé é é é é é é é é é é é é é ..) | 9 | |

7. What was your major (main) subject(s) during your teacher training course?

| | | |
|---|---|---|
| Science only | 1 | |
| Mathematics only | 2 | $V_8$ |
| Both Science and Mathematics | 3 | |
| Science and another subject other than Mathematics | 4 | |

8. Please indicate your post level in your position as a science educator.

| | | |
|---|---|---|
| Post level 1 science educator | 1 | $V_9$ |
| Post level 2 science educator | 2 | |

**SECTION 2: AVAILABILITY OF RESOURCES**

9. Please indicate whether you use a classroom or laboratory when teaching science

| | | |
|---|---|---|
| Classroom | 1 | |
| Laboratory | 2 | $V_{10}$ |
| Classroom but use laboratory for experiments | 3 | |
| Other (Specifyé é é é é é ..) | 4 | |

10. Do you have an allocated science classroom?

| | | |
|---|---|---|
| Yes | 1 | |
| No | 2 | $V_{11}$ |
| Not applicable | 3 | |

11. Please indicate the adequacy of the following resources in your science department by placing an X in the appropriate box according to the following meanings of the numbers.

| | |
|---|---|
| Very Poor | 1 |
| Poor | 2 |
| Average | 3 |
| Good | 4 |
| Very Good | 5 |

| RESOURCE | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| 11.1 Chemicals for chemistry practicals | | | | | | $V_{12}$ |
| Equipment for physics practicals | | | | | | $V_{13}$ |
| Chairs for science learners to sit | | | | | | $V_{14}$ |
| Tables or desks for science learners to write on | | | | | | $V_{15}$ |
| Tables or desks for learners to perform experiments | | | | | | $V_{16}$ |
| Science text books for new curriculum (NCS) | | | | | | $V_{17}$ |

| | | | | | | |
|---|---|---|---|---|---|---|
| 11.7 National curriculum statement documents for science grade 10 to 12 | | | | | | $V_{18}$ |
| 11.8 Human resource (Science educators) qualified to teach FET | | | | | | $V_{19}$ |
| 11.9 Science charts | | | | | | $V_{20}$ |

**SECTION 3: KNOWLEDGE**

12. Which section of science do you find difficult to teach?

| | | |
|---|---|---|
| Chemistry | 1 | |
| Physics | 2 | $V_{21}$ |
| Both Physics and Chemistry | 3 | |
| None | 4 | |

13. Science involves mathematical formulas, equations and calculations. Indicate how you find the mathematical part to teach.

| | | |
|---|---|---|
| Very difficult | 1 | |
| Relatively difficult | 2 | $V_{22}$ |
| Relatively easy | 3 | |
| Very easy | 4 | |

14. Please indicate how you would regard your knowledge in your current position as a science educator by placing an X in the appropriate box according to the following <u>meanings of the numbers:</u>

| | |
|---|---|
| Very Poor | 1 |
| Poor | 2 |
| Average | 3 |
| Good | 4 |
| Very Good | 5 |

| KNOWLEDGE | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| 14.1 Knowledge of subject matter | | | | | | $V_{23}$ |
| 14.2 Ability to answer subject related questions that learners ask | | | | | | $V_{24}$ |
| 14.3 New teaching methods where the learner is actively involved in activities of the science lesson while you facilitate | | | | | | $V_{25}$ |
| 14.4The new curriculum terminology | | | | | | $V_{26}$ |
| 14.5 OBE Principles | | | | | | $V_{27}$ |

**SECTION 4: TEACHING AND LEARNING**

15. Please indicate whether you are currently teaching science only or science with another subject(s). If you are teaching science and the other subject(s) indicate the subject(s)

| | | |
|---|---|---|
| Science only | 1 | $V_{28}$ |
| Science and é é é é é é é é é é é é é é é é . | 2 | |

16. Approximately, how many learners are in your largest science class?

| | | |
|---|---|---|
| 30 or less learners | 1 | |
| 31 to 45 learners | 2 | $V_{29}$ |
| 46 or more learners *( State Approximate . N0………………)* | 3 | |

17. Please indicate how you cope with the number of learners you teach by using the following rating scale

| | | |
|---|---|---|
| Very difficult to cope | 1 | |
| Relatively difficult to cope | 2 | $V_{30}$ |
| Relatively easy to cope | 3 | |
| Cope very well | 4 | |

18. In total how many science periods do you teach per week?

| | | |
|---|---|---|
| 30 or less periods | 1 | |
| 31 to 35 periods | 2 | $V_{31}$ |
| 36 or more periods | 3 | |

19. Please indicate how you cope teaching this number of periods by using the following rating scale.

| | | |
|---|---|---|
| Very difficult to cope | 1 | |
| Relatively difficult to cope | 2 | $V_{32}$ |
| Cope relatively well | 3 | |
| Cope Very Well | 4 | |

20. Do you sometimes have double period(s)/ double lesson(s) on your science timetable?

| | | |
|---|---|---|
| Yes | 1 | $V_{33}$ |
| No | 2 | |

21. During lesson changes, approximately how long does it take for you or your learners to move from the previous lesson to the new science lesson?

| | | |
|---|---|---|
| 0 to 5 minutes | 1 | |
| 6 to 10 minutes | 2 | $V_{34}$ |
| 11 to 15 minutes | 3 | |
| 16 or more minutes | 4 | |

22. What language do you use for teaching in your science class?

| | | |
|---|---|---|
| English only | 1 | |
| Your home language only | 2 | $V_{35}$ |
| Combination of your home language and English | 3 | |
| Other (specifyé é é é é é é é é é é é é ..) | 4 | |

23. How often do you give your learners problems that require mathematical calculations in science

| | | |
|---|---|---|
| Every lesson | 1 | |
| After completing one topic | 2 | $V_{36}$ |
| After completing two topics | 3 | |
| Other (Please specifyé é é é é é é é é é é é é é é ) | 4 | |

24. How would you rate the general attitude of your science learners towards the subject?

| | | |
|---|---|---|
| Very negative | 1 | |
| Negative | 2 | |
| Average | 3 | $V_{37}$ |
| Positive | 4 | |
| Very positive | 5 | |

25. Please indicate how often you use the following teaching and learning methods in your science lessons by placing an X in the appropriate box according to the following meanings of the numbers.

| | |
|---|---|
| Never | 1 |
| Seldom | 2 |
| Usually | 3 |
| Always | 4 |

| | 1 | 2 | 3 | 4 | |
|---|---|---|---|---|---|
| 25.1 Use a variety of teaching methods | | | | | $V_{38}$ |
| 25.2 Allow learners to discover the lesson content by using interesting teaching strategies | | | | | $V_{39}$ |
| 25.3 Succeed in capturing learnerôs interest in the learning material | | | | | $V_{40}$ |
| 25.4 Make use of different learning activities | | | | | $V_{41}$ |
| 25.5 Remedial Teaching | | | | | $V_{42}$ |
| 25.6 Expanded opportunities | | | | | $V_{43}$ |

26. How many times have you been absent from school this year?

| | | |
|---|---|---|
| 0 Days | 1 | |
| 1 to 5 Days | 2 | |
| 6 to 10 Days | 3 | $V_{44}$ |
| 11 to 15 Days | 4 | |
| 16 Days or more | 5 | |

**SECTION 5: ORGANISATIONAL SKILLS**

27. Please indicate how you would rate your skills in your current position as a science educator by placing an X in the appropriate box according to the following meanings of the numbers.

| | |
|---|---|
| Very Poor | 1 |
| Poor | 2 |
| Average | 3 |
| Good | 4 |
| Very Good | 5 |

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| 27.1 Planning of a science lesson | | | | | | $V_{45}$ |
| 27.2 Supervision of learners during experiments | | | | | | $V_{46}$ |
| 27.3 Classroom management during a science lesson | | | | | | $V_{47}$ |
| 27.4 Use of science resources/equipment | | | | | | $V_{48}$ |
| 27.5 Recording and filing | | | | | | $V_{49}$ |
| 27.6 Assessment of learners weaknesses and strengths | | | | | | $V_{50}$ |
| 27.7 Assessment of your own weaknesses and strengths | | | | | | $V_{51}$ |
| 27.8 Motivation of learners during the science lesson | | | | | | $V_{52}$ |
| 27.9 Maintaining science equipment/apparatus | | | | | | $V_{53}$ |

**SECTION 6: SCHOOL (DEPARTMENTAL) FUNCTIONING.**

28. How would you rate your head of department on the following traits? Please indicate by placing an X in the appropriate box according to the following meanings of the numbers.

| | |
|---|---|
| Very Poor | 1 |
| Poor | 2 |
| Average | 3 |
| Good | 4 |
| Very Good | 5 |
| Not Applicable | 6 |

| TRAITS | 1 | 2 | 3 | 4 | 5 | 6 | |
|---|---|---|---|---|---|---|---|
| 28.1 Friendliness to science educators | | | | | | | $V_{54}$ |
| 28.2 Helpfulness to science educators | | | | | | | $V_{55}$ |
| 28.3 Competence in science | | | | | | | $V_{56}$ |
| 28.4 Ability to inspire science educators | | | | | | | $V_{57}$ |
| 28.5 Planning of daily activities within the science department | | | | | | | $V_{58}$ |
| 28.6 Supervision of science educators or science learners | | | | | | | $V_{59}$ |
| 28.7 Communication skills within the science department | | | | | | | $V_{60}$ |
| 28.8 Decision making within the science department | | | | | | | $V_{61}$ |
| 28.9 Guidance of science educators | | | | | | | $V_{62}$ |
| 28.10 Ordering of science equipment | | | | | | | $V_{63}$ |

## SECTION 7: OPINION SURVEY

29. The following statements ask for your opinion about your school, its day to day activities and its community. Next to each statement please indicate your perception by whether you **strongly Disagree, Disagree, are Uncertain, Agree, or strongly agree** with an **X** in the appropriate answer box according to the following meanings of numbers.

| | |
|---|---|
| Strongly Disagree | 1 |
| Disagree | 2 |
| Uncertain | 3 |
| Agree | 4 |
| Strongly Agree | 5 |
| Not applicable | 6 |

| STATEMENT | 1 | 2 | 3 | 4 | 5 | 6 | |
|---|---|---|---|---|---|---|---|
| 29.1 I teach science at matric for examination purposes only | | | | | | | $V_{64}$ |
| 29.2 I allow learners to do experiments even if it takes time | | | | | | | $V_{65}$ |
| 29.3 I do experiments in science even if these may be dangerous | | | | | | | $V_{66}$ |
| 29.4 I do not allow learners to perform certain experiments even if it is my responsibility if accidents occur | | | | | | | $V_{67}$ |
| 29.5 I give learners opportunities to use equipment even if it is expensive | | | | | | | $V_{68}$ |
| 29.6 Field trips are important | | | | | | | $V_{69}$ |
| 29.7 I always use homework effectively to reinforce what is learned in class | | | | | | | $V_{70}$ |
| 29.8 I use only the lecture method in class | | | | | | | $V_{71}$ |
| 29.9 I give my science learners a chance to scrutinise their own performance to identify where they need help | | | | | | | $V_{72}$ |
| 29.10 The school timetable permits me to spend more time with weaker learners | | | | | | | $V_{73}$ |
| 29.11 My overall teaching load is fair | | | | | | | $V_{74}$ |
| 29.12 I assess learners according to the departmental policy | | | | | | | $V_{75}$ |
| 29.13 Hardworking science educators are recognized at my school | | | | | | | $V_{76}$ |
| 29.14 Science educators at my school are provided with necessary support | | | | | | | $V_{77}$ |
| 29.15 Science educators at this school work as a team | | | | | | | $V_{78}$ |
| 29.16 Opportunities for professional growth are available at my school | | | | | | | $V_{79}$ |
| 29.17 My head of the science department listens to suggestions of other science educators | | | | | | | $V_{80}$ |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 29.18 My head of the science department provides positive support | | | | | | | $V_{81}$ |
| 29.19 My head of the science department provides constructive feedback | | | | | | | $V_{82}$ |
| 29.20 My head of the science department tries hard to figure out how to do things in the proper way | | | | | | | $V_{83}$ |
| 29.21 The way this school is run makes it easy for science educators to perform their duties | | | | | | | $V_{84}$ |
| 29.22 OBE principles has little paper work | | | | | | | $V_{85}$ |
| 29.23 I am satisfied with my salary as a science educator | | | | | | | $V_{86}$ |

- Thank you very much for taking your time to participate in this survey.

*Appendix 3*

| | | | |
|---|---|---|---|
| | | | $V_1$ |

No

## QUESTIONNAIRE FOR SCIENCE LEARNERS IN GRADES 10, 11, AND 12

**INSTRUCTIONS**

a) Please give your response to each of the following questions.

b) At each question read all answers first and then indicate your answer by placing an X in only one box.

c) Answer all questions.

d) Your responses are confidential and no one in the school will see the answers you give, therefore be honest.

**SECTION 1: BIOGRAPHICAL VARIABLES**

1. Please indicate your grade

| | | |
|---|---|---|
| Grade 10 | 1 | |
| Grade 11 | 2 | $V_2$ |
| Grade 12 | 3 | |

2. What is your gender?

| | | |
|---|---|---|
| Male | 1 | $V_3$ |
| Female | 2 | |

3. How old are you?

| | | |
|---|---|---|
| 16 years and younger | 1 | |
| 17 years | 2 | |
| 18 years | 3 | $V_4$ |
| 19 years | 4 | |
| 20 years and older | 5 | |

4. Do you have a scientific calculator?

| | | |
|---|---|---|
| Yes | 1 | $V_5$ |
| No | 2 | |

5. How many times have you been absent from school this year?

| | | |
|---|---|---|
| 0 days | 1 | |
| 1 to 5 days | 2 | |
| 6 to 10 days | 3 | $V_6$ |
| 11 to 15 days | 4 | |
| 16 days or more | 5 | |

**SECTION 2: TEACHING AND LEARNING**

6. What teaching language does your science educator use during the lesson?

| | | |
|---|---|---|
| English only | 1 | |
| His/her home language only | 2 | |
| Your home language | 3 | $V_7$ |
| A combination of your home language and English | 4 | |
| Other (Please specifyé é é é é é é é é é é é é é é é é é é ) | 5 | |

7. Do you understand the teaching language used by your educator during the science lesson?

| | | |
|---|---|---|
| Yes | 1 | $V_8$ |
| No | 2 | |

8. What teaching language would you prefer your science educator to use during the lesson?

| | | |
|---|---|---|
| Your home language only | 1 | |
| English only | 2 | $V_9$ |
| Both English and your home language | 3 | |
| Other (Please specifyé é é é é é é é é é é é é é é é é é é | 4 | |

9. Do you experience difficulties in reading English, writing English or have numerical difficulties. Please indicate your answers in the appropriate answer boxes.

| | Yes | No | |
|---|---|---|---|
| 9.1 Difficulties in reading English | 1 | 2 | $V_{10}$ |
| 9.2 Difficulties in writing English | 1 | 2 | $V_{11}$ |
| 9.3 Numerical difficulties | 1 | 2 | $V_{12}$ |

10. How would you rate your science educator on each of the following traits? Please indicate by placing an X in the appropriate box according to the following meanings of numbers.

| | |
|---|---|
| Very Poor | 1 |
| Poor | 2 |
| Average | 3 |
| Good | 4 |
| Very Good | 5 |

| TRAITS | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| 10.1 Friendliness to science learners | | | | | | $V_{13}$ |
| 10.2 Helpfulness to science learners | | | | | | $V_{14}$ |
| 10.3 Ability to explain clearly during the lesson | | | | | | $V_{15}$ |
| 10.4 Ability to inspire science learners | | | | | | $V_{16}$ |

**SECTION 3: OPINION SURVEY**

11. The following statements ask your opinion about your school as well as the teaching and learning activities in your science lessons. Next to each statement please indicate your perception by whether you **Strongly Disagree, Disagree,** are **Uncertain, Agree, Strongly Agree** with an **X** in the appropriate answer box according to the following meanings of numbers:

| | |
|---|---|
| Strongly Disagree | 1 |
| Disagree | 2 |
| Uncertain | 3 |
| Agree | 4 |
| Strongly Agree | 5 |

| STATEMENT | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| 11.1 I experience enjoyment during science lessons | | | | | | $V_{17}$ |
| 11.2 My science educator inspires me to do my best all the time | | | | | | $V_{18}$ |
| 11.3Science lessons are interesting enough to keep my attention | | | | | | $V_{19}$ |
| 11.4 My science educator uses enough time for each topic. | | | | | | $V_{20}$ |
| 11.5 My science educator cares whether I understand | | | | | | $V_{21}$ |
| 11.6 My science educator always explains everything clearly | | | | | | $V_{22}$ |
| 11.7 We have done many experiments this year in science | | | | | | $V_{23}$ |
| 11.8 We get opportunity to perform experiments as individuals | | | | | | $V_{24}$ |
| 11.9 We get opportunity to perform experiments in groups | | | | | | $V_{25}$ |
| 11.10 We sometimes discover some of the science content on our own as learners | | | | | | $V_{26}$ |
| 11.11 Science is a theoretical subject | | | | | | $V_{27}$ |
| 11.12 Science has relevance in life | | | | | | $V_{28}$ |
| 11.13 I understand most of the science content we have covered in the lessons | | | | | | $V_{29}$ |
| 11.14 I have the confidence to openly express my ideas during the science lessons | | | | | | $V_{30}$ |

| | | | | | | |
|---|---|---|---|---|---|---|
| 11.15 I have the courage to ask questions during the science lessons | | | | | | $V_{31}$ |
| 11.16 My science educator treats all learners fairly in my class | | | | | | $V_{32}$ |
| 11.17 My science educator provides support to me in class to deal with problems | | | | | | $V_{33}$ |
| 11.18 My science educator is always on time for science lesson | | | | | | $V_{34}$ |
| 11.19 I am always on time for the science lesson | | | | | | $V_{35}$ |
| 11.20 My science educator always gives me homework | | | | | | $V_{36}$ |
| 11.21 I always do science homework in time | | | | | | $V_{37}$ |
| 11.22 After homework my science educator immediately marks my work | | | | | | $V_{38}$ |
| 11.23 My science educator provides me with useful feedback | | | | | | $V_{39}$ |
| 11.24 I understand the way my science educator teaches | | | | | | $V_{40}$ |
| 11.25 I am confident that I will pass science in my exams | | | | | | $V_{41}$ |

- Thank you very much for taking your time to participate in this survey.

*Appendix 4*

# GAUTENG DEPARTMENT OF EDUCATION

**JOHANNESBURG EAST DISTRICT**
**OFFICE OF THE DISTRICT DIRECTOR**
**POLICY PLANNING AND DISTRICT INFORMATION SYSTEMS MANAGEMENT**

*Enq: Keke Mofokeng* *011 666 9225*

**23 October 2009**

| | | |
|---|---|---|
| **TO** | : | **Eastbank Secondary** |
| **ATTENTION** | : | **Principal** |
| **FROM** | : | **Thabo Monyanyedi** |
| **SUBJECT** | : | **RESEARCH (UNISA MASTERS DEGREE STUDENT)** |

Dear Colleagues,

Kindly be informed that Mr Patson Muzah who is currently enrolled as a student doing Masters in Education: Natural Sciences in Unisa will be conducting a research in your school based on " **The Causes of Failure In Physical Sciences at Matric Level In Public High Schools of Alexandra."**

The purpose of the study is to analyse the school based factors that cause high failure rate in Sciences at Grade 12 in Public High Schools of Alexandra in order to suggest ways of improving the teaching and learning of Sciences. We as the Department believe that this will in turn increase the pass rate in this learning area.

FET Physical Science Educators and learners in your school need to complete the questionnaire and be interviewed by the researcher and it will take place on the following days **26 – 27 October 2009.**

The District would appreciate your participation in this regard to enhance positive results in Physical Sciences.

Hope for positive outcome at the end of the research.

Yours in Tirisano

**T. Monyanyedi**
**(CES: PP and DISM)**

*"At the Cutting edge"*

**Tel: 011 666 9225** **Fax: 0865945261**
**142 – 144 Cnr Fourth & Elizabeth Street**
**Email/.Lieketseng.Mofokeng@gauteng.gov.za** **Parkmore Sandton**
**www.education.gpg.gov.za** **2196**

*Appendix 5*

Patson Muzah
C/o Dr Nkopodi
UNISA
College Of Human Sciences
Dept.Of Educational Studies
**PRETORIA 0003**

24 October 2009

The Principal
Alexandra
**GAUTENG**

Dear Sir/Madam

**RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH IN FULFILLMENT OF THE REQUIREMENTS FOR A MASTERS DEGREE OF EDUCATION IN NATURAL SCIENCES STUDIES WITH UNISA**

I am a Physical Science and Technology Educator at Tharabollo secondary school in Palm Springs, in Gauteng Province. I am currently enrolled as a Master of Education (Natural Sciences) student with UNISA, under the supervision of Dr. Nkopodi in the Department Of Educational Studies.

As part of my studies I am required to undertake research in fulfillment of the requirements for attaining my degree. The title of my research is; **"An exploration into the school related factors that causes high matriculation failure rates in physical sciences at public high schools of Alexandra Township."**

The purpose of the study is to investigate and analyze the factors that cause high failure rates in sciences at matriculation level in public township high schools of South Africa. I will also be looking at what factors contributed to the success of those students who passed.

To complete this research, physical science educators and learners in public high schools of Alexandra Township need to complete the questionnaires and interviewed in certain circumstances.

I have identified your school as one of the participants on this project. Permission has been sought and granted by the relevant authorities as per enclosed letter from the District Office dated 23 October 2009.

I therefore request your permission to undertake this research at your school. Participation by your school is voluntary. Anonymity and confidentiality is assured for all participating schools and respondents.
Thanking you in advance for your assistance,

Yours faithfully,

Patson Muzah

UNISA STUDENT ID 41492919
Mobile: 072 434 8800
Email: patsonmuzah@yahoo.com
I, Mr/Mrs ____________________________________ the principal of _______ secondary school have granted Mr. Patson Muzah, who is a student with Unisa, permission to undertake a research study for the purpose of his studies with Unisa.

Signature ____________________________

Date_________________________________