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An investigation into the relationship between what learners find relevant and how they perform in the grade 11 science curriculum

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CHAPTER ONE – INTRODUCTION

1.1 GENERAL STATEMENT OF THE PROBLEM

South Africa is a young democracy in which change is being implemented in many areas, including education. In an attempt to address the inequalities of the past, and in line with trying to improve mathematics/science results, education policy has changed. The current emphasis in South African education is on relevance and learner-centeredness, with one of the prerequisites in terms of the education policy for general education and training (GET), being that science education should be *relevant*. Linked to this issue of relevance is the current concept of scientific literacy – making science accessible and appropriate for every citizen, not merely the scientific elite.

Another factor driving curriculum change is the desire to improve on South Africa's dismal performance in the recent Third International Mathematics and Science Study (TIMSS). TIMSS is an international programme that assesses and ranks the performance and achievement of participating countries, providing an international performance standard that provides a measure of efficacy of education systems. In 1995 45 countries participated and South Africa fared very poorly, creating great concern in the mathematics/science education fields. This performance could be due to a variety of factors including teaching practices, insufficient resources, student attitude, inappropriate curriculum, home environment, peer environment and socioeconomic status. One of the responses taken by the South African Department of Education has been to create a science curriculum that seeks to be relevant.

This research project takes the curriculum in particular as its point of departure in an attempt to assess whether what learners envisage as relevant has any relationship to their performance in science. It is hoped that this may cast light on the TIMSS results

by indicating that in South Africa items tested for are not those seen to be relevant here.

Over the past three decades, gender and performance in mathematics/science subjects has also often been the subject of discussion by teachers, researchers, and policy makers (Johnston and Dunne, 1996). Girls underachieving in these subjects was a trend at one stage, with much debate about why and ways to improve their performance. Once again policy in South Africa seeks to engender equity, this including equality in terms of gender (National Committee on Further Education, 1997). Perhaps a relevant education would address gender inequalities in science as well. In some countries the implementation of strategies has had the effect of the trend being replaced in quite the reverse way, with boys underachieving now, causing much research in attempting to unravel this reversal (Murphy, 1996).

This study has attempted to determine whether there are differences in the ways that boys and girls choose science topics, i.e. do they prefer different content? Consequently the study has sought to identify links between gender, relevance and performance.

Education in general, and science education in particular, emphasizes the importance of relevance in the curriculum. 'Relevance', 'learner centered education', 'inquiry based teaching/learning', and 'STS' approach to science teaching, are a few of many recent buzzwords in the teaching and learning of science. These terms represent an attempt in science education to improve learners' performance in science. However 'relevant science' or 'relevance' in a science education context can be somewhat vague. Relevant to whom? Relevant to what? What in fact does this relevance mean? The Oxford dictionary (1978) version of relevant is "pertaining to the matter at hand". The popular sense of the term 'relevant' science is 'useful' science or science which relates to life outside the curriculum. Science that moves away from

pure unrelated content, to science that is related to a learner's day- to- day experiences, could be considered to be an appropriate view of relevant science.

Science is one of the major cultural achievements of western societies. Cobern & Aikenhead (1998) view teaching and learning science as cultural transmission, where culture relates to an ordered system of meaning and symbols, in terms of which social interaction takes place. A failure to engage the interest of societies' youth represents a threat to the culture (Osborne and Collins, 2001). Recently there has been a disengagement of learners from science. Sjoberg (2002) has suggested that there is a current disenchantment with science. This seems to apply in the context of South Africa as well, where there are a relatively small number of learners choosing to do science as a matriculation subject. Despite the many hours learners spend studying science, only few appear to relate to these subjects in such a manner that it becomes part of their essential worldview and advances their education in a larger sense – one in which they make a connection to the subject matter so that it becomes a source of inspiration and occupies a formative part of their life (Kozoll & Osborne, 2003). What then can be done to address the issue of engaging learners' interests in science? One possibility would be to determine what does interest science learners, and use this in designing a curriculum that takes into account their perspective. Hofstein & Yager (1982) are of the opinion that a personally relevant science curriculum is likely to have high motivational power for a broad range of learners.

Trowbridge and Bybee (1990, p427)) pose the question "what science is of most worth to the citizen?" They propose the answer also – "science that includes an emphasis on personal, social and career goals" (*Ibid*, p423). This type of science education they term scientific literacy, which continues to have currency in present day science education. Scientific literacy is identified by the National Science Teachers Association (NTSA) as the most important goal in school science education: "The major goal of science education is to develop scientifically literate and personally concerned individuals with a high competence for rational thought and

action" (NTSA, 1971, 47). However, scientific literacy means different things to different people. Most people understand the term to imply a broadly functional understanding of science, for example Bybee & DeBoer (1994, 377) state that "science knowledge was to be used to answer important questions that people encountered in their everyday lives, not just answer questions about theoretical science". Put differently, scientific literacy is about using scientific knowledge in daily decision making, in interacting with society and the environment. Science education reforms thus seek to enhance scientific literacy for all learners. Within this framework, reformers hope to ensure that all learners obtain the scientific knowledge, skills, and habits of mind needed to make informed personal decisions, and become productive members of society. If scientific literacy is an aim of science education, then one approach towards obtaining this goal would be to make the science curriculum relevant to the lives of the learners.

As already noted, South Africa is a developing country, implementing reform in many fields. Many of these changes are directed in an attempt to allow equal opportunities for all citizens in all aspects of life. The current emphasis in South African education is on resolving the imbalances of the past, while at the same time seeking to participate on a global level, and to keep up with the technological and scientific world. One of the solutions towards achieving both goals could be by making education relevant and learner-centered for both boys and girls.

1.2 RESEARCH QUESTIONS

The scope of this investigation is the relationship between relevance, gender and performance. There are thus two aspects which will be investigated in this study – firstly possible links between relevance and performance, and secondly, the impact of gender on these links. The questions that are being asked seek to discover if there is a connection between what learners find relevant in the grade 11 science curriculum, and how they actually perform in terms of the assessment of what is learnt in the

classroom. The research questions related to gender involve discovering if there is a pattern to be found in the type of topics that boys/girls are interested in and whether they choose topics differently. This then links back to the first question, i.e. is there a relationship to be found between what each gender finds relevant, and how they actually perform in the examination?

The research questions are thus:

1. What science topics in the current grade 11 science curriculum do learners claim to find relevant?
2. Which topics are linked to poor performance?
3. Is there a relationship between what learners see as relevant and their actual performance in these topics?
4. Are there gender differences with regard to questions one and two above?
5. What explanations do the learners give for their choices?

1.3 RATIONALE

The analysis of the performance of individuals and groups (boys/girls) could prove valuable to curriculum planners. It could reveal which areas of the science curriculum are responsible for the greatest learning difficulties and where curriculum development efforts should be concentrated. Use could also be made of performance data to improve planning decisions. This investigation thus has potential significance and importance as follows:

1.3.1 Amending the existing curriculum

The study is currently important in South Africa in that the entire education system is being revamped, with the emphasis on 'learner-centeredness' and 'relevance'. The current focus is on addressing the inequalities of the past, be they racial, religious or gender, and the results of this study could perhaps serve to help reflect on changes that are needed in the existing science curriculum.

1.3.2 Addressing the poor performance in mathematics/science

South Africa did not perform as well as expected in the 1995 TIMSS survey, making it evident that investigation into the causes of the poor performance is required, with the subsequent development of a performance improvement plan. One of the areas of investigation regarding the improvement of the TIMSS results is the current curriculum. This study highlights what aspects of the existing curriculum the sample of learners found relevant, and what they did not. The results may be useful in designing a curriculum, which through being relevant, might augment performance.

1.3.3 Addressing the question of 'does relevance really matter?'

Relevance is a popular slogan in science education today and there is much emphasis on making education 'relevant'. This study aimed to determine whether what learners think is relevant is actually reflected in their performance. A lack of correlation between what learners say they find relevant and how they actually perform could lead to investigating other factors that might affect performance.

1.3.4 Investigating the impact of gender on topics found relevant

What is the evidence for suggesting that school science is gender-sensitive? Are girls performing as well as boys in mathematics/science subjects and do boys and girls choose topics differently, in terms of their ideas of what is relevant and what is not? Could the explanation for what is found relate to the type of topics found in the existing science curriculum? Differences might show that the existing topics are possibly more oriented towards a particular gender.

1.3.5 Personal significance

The study is important to me as an educator in the field of Physical Science education, as this information could result in my using a teaching approach that is more appropriate to learners' needs. Knowledge about what each gender prefers or dislikes and the reasons for this, allows for an improved strategy when teaching particular sections that have been identified as "not relevant".

1.4 STRUCTURE OF THE RESEARCH REPORT

Chapter 2 provides a literature review highlighting international views on relevance and performance in science education, as well as studies in South Africa. Issues of scientific literacy, science for all, gender, international studies (e.g. TIMSS study) and issues related to performance are discussed. The theoretical framework that underpins this investigation is also provided. The literature review provides a detailed look at relevance as pertains to this investigation.

Chapter 3 considers the general usage of quantitative and qualitative research methodology. Advantages of specific methods are discussed. This chapter also outlines the research approach. The site and sample selection, data gathering techniques, tools, actual implementation, methods of analysis, statistical tests used and ethical considerations form the essence of this chapter.

Chapter 4 gives the results. This chapter presents data that has been analysed in the form of tables and graphs. These are presented in the order of the research questions.

Chapter 5 presents a discussion on the findings of the data analysis. A systematic attempt is made to answer the research questions, beginning with research question one, followed by a discussion on the data related to each subsequent research

question. The chapter ends with a discussion on the limitations of the methodology, and factors that might have impacted on the results that were obtained.

Chapter 6 is a reflection on the study, a conclusion, and recommendations are provided. Possible topics for future research that arise from this study are mentioned.

CHAPTER TWO – LITERATURE REVIEW

2.1 INTRODUCTION

Recent efforts in science education have focused on making the curriculum more relevant for many reasons, including low levels of achievement, international comparisons, economic competitiveness, workplace preparation and the need for scientifically and mathematically informed citizens. These concerns become more critical as the public, and the profession becomes more vocal in calling for improved teaching and learning of science. This research project revolves around relevance and learners' performance in science. More specifically, does relevance of science content affect performance, and does gender affect performance in science?

There are many different views on relevance – it is an ambiguous term. A discourse on relevance begs the questions (i)'relevant to whom?' society, politicians, scientists, teachers, parents, curriculum developers? and (ii) 'relevant to what?' careers, day-to-day experiences, prior knowledge, informed citizenry?

The thrust of this study, in terms of relevance and the curriculum, is one of relevance to the learner: does the curriculum relate to the learners' life, experiences, hopes and dreams, and following from this, does performance in an examination improve if the learner relates science content to his/her life world? The educational issue here is one of engaging learners' self-identities. How can school science do this, or is it even feasible? This chapter contains an overview of the literature that provides the background to the current study, beginning with a discussion on *what relevance is.* This is followed by a discussion on *why there is a need for relevance,* including reasons such as current discontent with science, globalisation, scientific literacy, TIMSS, South Africa's reforming education system, social changes, the exponential development of the scientific/technological age etc. The chapter continues with a discussion on gender issues in science education, since one of the outcomes of this

project is to determine if there are gender inequalities in performance in science in this sample. Issues related to gender could be addressed with a relevant science curriculum. The chapter concludes with the theoretical framework that underpins this study

2.2 GOAL OF SCIENCE EDUCATION

An important goal of science education is to help learners develop a valid knowledge of science and be able to creatively apply that knowledge in various settings. Definitions of science vary from one scientist to another. To some, science is an organized body of knowledge. To others it is a search for meanings or explanations about natural phenomena, while still to others it is an attempt by human beings to organise their experiences with nature into meaningful systems of understanding (Ogunniyi, 2000). Throughout the history of science education, three major goals for learners have been (1) to acquire scientific knowledge, (2) to learn the procedures or methodologies of science and (3) to understand the applications of science, especially the relationship between science and society (Bybee & Ben-Zvi, 1998). The totality of an education in science is equally as much oriented toward social justice, critical democracy, empowerment, action-taking, and investing in our future's intellectual capacity as it is about constructing conceptual understandings of the world. Education is about hope, dreams, aspirations, and struggle. Education is about expanding upon the knowledge of lived experiences that learners bring to situations; it is about "opening doors, opening minds and opening possibilities" (Kyle, 1999, p258). These noble endeavours require a curriculum that answers these needs – i.e. a relevant curriculum.

2.3 WHAT IS RELEVANCE?

Traditional school science attempts to prepare learners for the next level of science courses by emphasizing content acquisition. The ideology of "the pipeline" or

traditional schooling seems to have been the aim of science education, whereby capable learners are channeled into engineering and science programs (Aikenhead, 2006). However most high school learners pursue goals outside this pipeline. Aikenhead states that for many of these learners science is a foreign culture; they prefer a science education for everyday life, seeing science as a human endeavour, embedded within a social milieu of society. Aikenhead maintains that most research into learners' views of the science curriculum has found it to be socially sterile, impersonal, frustrating, boring and dismissive of learners' life-worlds and goals (Ibid.). It would appear that what is needed is a relevant science education, one which can acknowledge the fine line between scientific literacy for all, while simultaneously addressing the issue of preparing future scientists and science career minded learners. Sjoberg (2002) also believes that there is a need to make science curricula more relevant, meaningful and adapted to different groups, indicating that relevance implies the importance of knowing more about the views, experiences and perspectives of the learners.

There seems, however, to be an issue regarding consensus among people involved in science education about 'relevance' (Smit, 1999). Teachers, science educators, parents and learners seem to have differing ideas about what a relevant science education might mean. Various literature reviews (Jansen, 1999, Driver et al, 1994) link relevance to the current socio-political situations or relevance to the nation's economic status. The suggestion by McGinn and Roth (1999) is that by forging stronger links between science in everyday life and science in schools, learners can be supported to move along in a manner that leads from the classroom to participation in different non-school communities. They believe that a foundation for competent participation in communities where science is created and used should be provided, in other words, a curriculum is needed that answers the country's needs. To the layman, relevant science means science that is worthwhile or useful. Learners and parents regard relevance in light of entry into the job market (Rollnick, 1998). In Nicolson & Holman (2003) it is mentioned that learners and parents value and appreciate the real-

life applications of science more than any other aspect. The more abstract topics are not perceived to be useful for later life.

Aikenhead (2006) questions the efficiency of teaching for meaningful learning in the context of the traditional science curriculum. He distinguishes between "canonical science" i.e. traditional science content, and "humanistic science", i.e. the alternate to the pipeline ideology of traditional school science. He believes that there is a greater advantage to teaching fewer canonical science concepts chosen for their relevance to daily life. This belief is supported by research studies based on standardized achievement tests of traditional science where studies showed no significant difference in learners' scores when instruction time for the canonical content was reduced to make room for more relevant content (*Ibid*.).

2.4 WHY IS THERE A NEED FOR A RELEVANT SCIENCE CURRICULUM?

Sjoberg (2002) has noted that there is little doubt that in many countries there is a current disenchantment with science. In addition Aikenhead (2006) has pointed out that deficiencies in the traditional science curriculum have impacted on peoples' success in learning and using science. At a time when more than ever the need exists for a scientifically literate society, the trend seems to be one of science education suffering from a lack of positive interest by learners. The source of this lack of interest has to be comprehended if any headway is to be made in raising science to the status it deserves.

Where does the dissatisfaction arise? There are many causes that can be considered. To begin with, science teaching/learning as a discipline is very logical, very systematic, but involves much study for little relationship with the world around us (Holbrook, 1992). There is little connection between learned science content in the classroom, and living in the world out there. The present approach to teaching and

learning science seems to be one of 'learning science for the sake of science'. Yet the emphasis should be on learning science as an expression of the structures produced and valued by scientists (Yager, 1992). Most learners tend not to learn science meaningfully, often playing 'Fatima's rules', (Aikenhead, 2006) meaning learning merely to pass the exams. They do not integrate it into their everyday thinking. It is often not relevant to the day to day functioning of the average person, and hence has become science that is unimportant to many learners. It is perhaps due to this that there are current noticeable negative trends regarding science at schools, viz. a decrease in enrolments, achievements and career choices (Aikenhead, 1994).

Furthermore there seems to be little connection between science and technology. The focus is on science as a pure subject rather than an applied subject (Holbrook, 1992). In addition teaching and learning are usually exam oriented. This notion, together with the belief of many learners that science is difficult, and that it lacks relevance to daily life, are just some of the factors that are thought to contribute to the demotivation of learners (Duggan and Gott, 2002). Hence science has become unimportant to many learners. The curricula have been designed in a manner that favour those learners intent on pursuing science-oriented careers in later life. The science that is being taught is 'inaccessible' to ordinary learners. Access to science education is a necessity.

The concept "Science for All" was initiated in the 1960's. At this time a need was seen by the international education community for scientific literacy for all – not just for those learners who would go on to further studies, and perhaps careers in science, but scientific literacy also for the vast majority who would not undertake any further formal studies (Nicolson and Holman, 2003). Fensham (2003) argues that since societies everywhere are being increasingly permeated by the ideas and products of science in the form of technologies, all future citizens will be better able to cope if they have some knowledge and confidence about science. "Science for All' is contrary to 'Science for Some' (especially potential scientists). Offering all learners

narrowly defined programmes focused on preparation and selection for tertiary science study is not 'Science for All.' Fensham's notion (*Ibid*.) is that the needs of the majority of learners in secondary schools has not been in the forefront of the curriculum designers, and that they were being poorly served by the abstract and academic content that had become the basic nature of school science. 'Science for All' is an important reason for promoting relevant education. An education system that has "Science for All" as its focus would be one that promotes the concept of relevant science education. Fensham (*Ibid.*) identifies two groups of demands that science curricula might meet. One concerns political, economic and subject-maintenance demands, the other cultural, social and individual demands. Current curricula concentrate on the first group and ignore the second. These curricula are then unbalanced, and leave the learners with distorted understandings of science.

Sjoberg (2002) insists that following the table of contents in science textbooks—topic by topic—neither promotes the integration of worlds, nor does it develop a love affair with science. For this to happen requires something more than what school science currently offers. The 21st Century Science project team (2003) mentions that school science has to do two jobs. For some learners– a minority – it provides the first stages of their training as a scientist, or for a career that involves science. For all learners , it aims to provide the kind of 'scientific literacy' that they need to play a full part in modern democratic society where science and technology play a key role in shaping our lives as active and informed citizens.

The promotion of scientific literacy in science education requires the introduction of relevant science education. Scientific literacy is a concept that has as its central premise the issue of relevance. The term scientific literacy has been used for some time, with many definitions for it, for example "the capability to function with understanding and confidence, and at appropriate levels, in ways that bring about empowerment in the made world of scientific and technological ideas" (Harlyn 2003, 93). Another more recent but still evolving definition of scientific literacy mentioned

in Harlyn (*Ibid*., 94) is "the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity"

The 1990's saw an intensive debate about scientific literacy, inspired by concerns about the educational demands of the twenty-first century. Later these discussions were fuelled by the results of the TIMSS project that uncovered large deficiencies in the state of scientific achievement in many countries. The following four arguments were provided by Fensham (2003) for the need to improve scientific literacy: (1) the economic argument – modern societies need scientifically and technologically literate workforces to maintain their competencies; (2) the utility argument – individuals need some basic understanding of science and technology to function effectively as individuals and consumers; (3) the cultural argument – science is a great human achievement and it is a major contributor to our culture; (4) the democratic argument – citizens need to be able to reach an informed view on matters of science-related public policies in order to participate in discussions and decision making. Furthermore the following core ideas of 'Science for All' are included: (i) the likely usefulness of the learning in the learners' everyday life out of school and (ii) the chance that it will produce a response of wonder and curiosity about nature (Fensham, *Ibid*.). Schools will have to cope with social change, of having to provide science as a meaningful study for all learners, rather than the small minority who might become the next generation of professional scientists. This change makes concentration on theory less appropriate than a focus on the relation between science and technology and social questions such as the balance between the environment and the maintenance of industrial civilization.

Hunt (2003) suggests another reason for the need for relevance in science education would be that perhaps it would address the needs of young people more than the current traditional system does. He insists that the key to higher achievement is to put the needs of learners at the center of educational provision. This would involve

tackling long-standing problems effectively, for example disaffection with schooling. It implies addressing some newer challenges arising from young people's increasing expectations to control their own lives, to exercise choice and to be able to change their minds. It also means that it is vital to ensure that young people, their parents and teachers have a very much better appreciation of what their real needs are and where their interests lie (Hunt, *Ibid*.).

Learners' opinions also encourage the need for relevant science education. Vithal and Alant (2004) mention that science and mathematics education research is inundated with research on learners' perceptions, attitudes, beliefs, and their understanding of a vast array of skills and concepts in mathematics, biology, physics and chemistry. However such voices are often restrained and constrained within the boundaries of the research question (Vithal and Alant, *Ibid*.), rarely venturing beyond asking about whether learners in fact value or consider important or relevant the questions being posed. Whitehead and Clough (2004) suggest that there is a broad range of players implicated in this silencing – from researchers to curriculum policy makers to textbook publishers. They insist that studies like the TIMSS study where learners' voices are made into quantitative scores dominate the imagination of the public and policy makers. Poor performance is characteristically blamed on poor learning, but the question of what learners really think and feel about the mathematics and science that they learn about in school remains largely unanswered. Whitehead and Clough (*Ibid*.) further maintain that if our desire is to make schools places where learners want to and are able to learn science, with a view to maximizing academic attainment and raising standards, then new participatory forms will be essential. If realized this would provide evidence of more democratic modes and will also result in innovatory practices, such as content dealing with relevant issues which are currently absent. Learners can move forward their learning to achieve goals that are meaningful to them and which motivate them. In Cook-Sather (2006) it is mentioned that the most promising strategies for learning involved treating learners as capable persons, capitalizing on their knowledge and interests, and involving them in

determining goals and learning methods. Cook-Sather (*Ibid*.) further mention that in much legislation learners' voices, their words, presence, power is missing, insisting that this trend is consistent with that of educational research being conducted *on* and not *with* learners

It is important to caution against over emphasizing the aspect of student involvement, however, meaning that there are negative aspects to the 'student voice'. A concern among some proponents (Cook-Sather, *Ibid*.) of the 'student voice' is that an oversimplification of issues in changing school culture to make it more responsive to learners will lead to tokenism, manipulation and practices not matching ideals. However, if conscious effort is made to guard against these occurrences, there may be more good than otherwise that can be achieved, out of listening to what the learners have to say.

2.5 EDUCATION IN SOUTH AFRICA

South Africa is into its second decade of democracy and change. Not only was the education system of the past seen to advocate divisions, it was also seen to be flawed in other fundamental ways that were in need of change. The emphasis on the rote memorization of content, culminating in the matriculation examination, for example, was seen to produce passive, non-thinking citizens. Teachers were also seen to be technicians rather than professionals, required to teach to a prescribed syllabus (Rogan, 2004).

From an economic standpoint it was believed that South Africa's inability to generate an economic growth rate to sustain all of its redress needs was largely due to the lack of relevant skills (Jansen, 1999). The education and training system was designed to meet the needs of an outdated specification and this rendered the economy incapable of competing with workforces that were trained to be "self-directed, innovative and reflective" (p147). Jansen (*Ibid*.) mentions that it was believed that the economy

should grow at approximately 6% in order to create sufficient jobs to drastically reduce unemployment levels in the country; South Africa's economy was growing at a rate of about 3%. For this to change required a transformation of the Labour Market which implied a change needed in the type of South African education system.

South Africans enthusiastically embraced the opportunity presented by the formal ending of apartheid and ten years on, people look forward to a brighter future. Education in schools, colleges and universities is highly sought after and much prized, despite there being many challenges and constraints (Johnson, Monk, Botha and Hodges, 2004). Part of the massive challenge faced by this developing nation is that of providing a sound education system. This challenge, also faced by many other countries, revolves around a central issue – what should an education system provide to prepare its future citizens for adult life and for life long learning? In South Africa the response has been the development of Curriculum 2005 (C2005) and its subsequent revision, the National Curriculum Statement (NCS).

The solution proposed in C2005 was to adopt Outcome-Based Education (OBE) where the critical outcomes are clearly modeled on a Western model, depending heavily on borrowing from different international contexts, especially from New Zealand and Australia (Breidlid, 2003). According to C2005, OBE should "ensure that learners gain the skills, knowledge and values that would allow them to contribute to their own success as well as to the success of their family, community and the nation as a whole" (OBE Educator's Guide, 2002). OBE thus prescribes an approach where educators are expected to depart from the formal curriculum and its content categories as the starting point and purpose of learning, and rather begin from the real world contexts where learners demonstrate what real people do to be successful on a continuous basis in their career, family, communities (OBE Educator's Guide, 2002). It is claimed by Jansen (1999) "that outcomes would displace an emphasis on content coverage, outcomes would make explicit what

learners should attend to, outcomes signal what is worth learning in a content-heavy curriculum, outcomes can be a measure of accountability" (p146). The National Curriculum Statements emphasise the following principles: (NCS, 2003)

- Outcomes based education
- Integration
- Human rights and inclusivity
- Awareness of Indigenous Knowledge Systems
- Social transformation

These principles, among others, revolve around values, skills and knowledge, in other words: doing, knowing and valuing.

OBE was implemented in an effort to address the inequalities of the past. However, another possible motivator for a change in the education system could be South Africa's dismal performance in international mathematics/science surveys. In a recent study by Osborne (2003), South Africa scored lowest on almost every measure of learner performance in international and comparative benchmarks. Osborne (*Ibid*.) points out that despite the questioning of the credibility of these studies, the results have substantive policy implications in many countries.

2.6 SCIENCE IN SOUTH AFRICA

Changing education systems are driven by changing social forces. At different times different purposes for science education come into favour. The most visible effect of change in purpose is new content but a subtler and more fundamental effect is a shift in the emphasis placed on the curriculum. In South Africa, as a newly independent democracy, facing challenges in addressing issues of the past, particularly in relation to the accessibility of science to all learners, a different purpose was required. The system of education and training, according to the National Committee on Further Education (1997) had failed the majority of the population, and this was a significant source of popular resentment and frustration. This was reflected in TIMSS (The Third International Mathematics and Science Studies), the recent international

mathematics/science survey that exposed the low standard of achievement by learners in South Africa in mathematics and science. It provided independent international comparisons, including more than half a million learners in about 15000 schools, which were drawn from 45 countries (Papanastasiou & Zembylas, 2002). The aim was that each nation would be able to judge its education system by its TIMSS indicators. Only one African country (South Africa) participated – and performed poorly. What caused the poor performance? Was it due to the curriculum, which could have been more relevant, hence producing a better outcome?

Sjoberg (1996) believes that this outcome was not unexpected, and that it should be understood in the context of the fact that results were obtained from a representative sample of South African school children shortly after the fall of apartheid. Sjoberg (2002) believes that large-scale comparative studies like TIMSS have limitations and side-effects. The international and cross-cultural nature of TIMSS-like studies has necessarily implied the development of items that can be used independent of educational or social context to avoid cultural bias. Hence test items tend to become decontextualised and rather abstract (Sjoberg, 2002). This lack of social context may run contrary to national or local traditions. This could have bearing on South Africa's poor performance in the TIMSS survey. However these results are looked upon though, as legitimate or not, there is a pressing need to be part of the global community.

In the context of a global economy, and the advent of the information age, South Africa is faced with the choice of developing the country to a level of international competitiveness or becoming one of the backwaters of the world economy (National Committee On Further Education, 1997). Economic competitiveness depends on knowledge-based industries, science and technology. Science education is prominent as the most critical sector of education needing improvement. The current status of science education in South Africa, together with other problems like communications infrastructure create difficulties for the nation to compete internationally. There are

international surveys, like TIMSS, producing common standards and frameworks in the science curriculum – but there are also local demands, with the need to satisfy local cultures and economies. The challenge lies in deriving a curriculum that reduces the tensions between global and local, more than the issue of science for all and scientific literacy. Creating a workable curriculum requires insight into the factors that affect performance, and subsequent adaptations of the curriculum so that improved performance is noted. One of the possible factors that might work would be a relevant science curriculum.

2.7 TIMSS

TIMSS is a large-scale comparative study, and is conducted internationally. It was conducted in 1995, 1999 and 2003. The main aim of the TIMSS studies is to provide trend information on learner achievement in mathematics and science. These studies are conducted every four years. For South Africa, TIMSS 1995 offered the first national analysis of learner achievement, and the subsequent international studies have provided a means of assessing local performance as well as providing an international benchmarking ability (Reddy, 2006).

South Africa's performance in 1999 and 2003 has been very similar. In both studies South Africa achieved the lowest score in mathematics and science. The South African average score for TIMSS 2003 was one point higher than for TIMSS 1999, The difference was not significant (*Ibid*.). South Africa's performance was poor, and hence warrants an investigation into root causes for this situation.

2.8 FACTORS AFFECTING LEARNING

Learners learn science with varying degrees of success. The difference in success is often attributed to differences in the learners' abilities, effort, and the learning environment of the school and the home. In Sternberg and Zhang (2001) it is

suggested that the act of learning involves interaction among three factors: (a) the teacher's knowledge and methods of instruction, (b) the curriculum (skills and knowledge to be acquired), and (c) the student's abilities, interests and learning styles. Effective learning occurs when there is a compatible match among these factors. However, factors such as student's abilities and personalities may be beyond a teacher's sphere of influence (Chin, 2003). There are some factors (input measures) that can be managed to improve performance such as teaching methods, curriculum content, resources, time spent on the subjects, teacher qualifications and attitude. Bennett (1999) argues that the most important single factor influencing learning is the active engagement of the learner with the material – and that placing the science being studied in context, or relating it to pupils' everyday experiences, does help engage their interest. Yoloye (1998) identifies motivation – the desire to learn as a prime factor affecting learning – maintaining that interest in the material to be learned is the best stimulus to learning, rather than external goals such as grades. In order to know that which relates to learners' everyday experiences/life, one needs to listen to the learners' voices. Bennett's ideas of active engagement with learning material, and Yoloye's thoughts on motivation could both improve learning with a relevant curriculum.

Van den Akker (1998) mentions curriculum as a plan for learning, or the content and purpose of an educational program together with their organization. Sayed (2003) incorporates the political into what is meant by the curriculum by noting that curricula have to address the varied interests of their expanded learner-base, among other things. Slabbert & Hattingh (2006) mention that the vision and philosophies that underpinned the science curriculum in the past were not as plagued by crisis as much as is currently experienced - they served the needs of their eras effectively and efficiently. However, as pointed out by Slattery (in Slabbert & Hattingh, 2006), those visions, despite their contributions to previous generations, have proven to be impotent in the face of growing turmoil in the modern world. The National Committee On Further Education (1997) claim that curricula are outdated and out of

touch with the changing needs of society and the economy, and that they have an academic bias towards higher education rather than vocational education and training or the world of work.

The past decade has seen a renewed interest in the development of science curricula in many areas around the world (Rogan, 2004). In many cases these curricula are well designed and the aims they intend to achieve are laudable (Rogan, *Ibid*.). However these curricula have often been driven by external policy mandates that legislate when, what, how, and why changes occur. Rogan (*Ibid*.) further states that these approaches, though required to promote increased achievement, have been overwhelmingly top down. Teachers and learners, the primary beneficiaries of increased attention to the nature and need of scientific literacy, have become recipients, rather than co-partners of reform, with a perspective of those from outside looking in. Van den Akker (1998) echoes this sentiment, claiming that effective curriculum change requires consideration of a range of stakeholders' understandings of discipline knowledge. Slabbert & Hattingh (2006)) found that recent research on cognition demonstrates how significant it is to listen and hear what children say about their experiences. The children are intelligent and realistic. Listening to them, studying their minds and trying to understand the research that reveals their thoughts, might clarify what their ideal educational future would be (Slabbert & Hattingh, *Ibid*.). Reformers seeking to increase student understanding and interest are looking to collaborative partnerships to support improved science, technology and mathematics teaching. By listening to all the voices, a curriculum that is dynamic, flexible and responsive to rapid changes in all areas of life, including work, life, morals and leisure can be planned (Slabbert & Hattingh, *Ibid*.). In Kinchin (2004) a curriculum of the future is described, in which emphasis is placed on a transformative concept of knowledge; the creation of new knowledge; the interdependence of knowledge areas and the relevance of school knowledge to every-day problems. To achieve such a curriculum, the voice of the learners needs to be heard.

2.9 PERFORMANCE

The analysis of the performance of individuals and groups can prove valuable to planners (Lewin, 1993). Research on performance can show which areas of the science curriculum are responsible for the greatest difficulties, where curriculum development efforts should be concentrated. This research project investigates learners' performance in various topics as well as the relationship between relevance and performance, and gender and performance. As such, performance in the examinations forms a pivotal role in the study. Successful performance can be deduced from tasks such as tests, examinations, assignments, verbal presentations etc. where success is defined using numerical values or criteria-based assessment. Success can also be measured using less tangible, emotional indicators as pointed out by Cousins (2007). For the purpose of this study, the notion of educational success focuses on the performance in the examination, since data was needed that could quantify and measure educational success.

2.10 GENDER AND PERFORMANCE

Willis (1996) mentions that achieving gender equity in science education has been a high priority in many countries, with intervention programs aimed at improving participation by the disadvantaged group. There has been a rapid increase in the attention paid to gender issues – which has occurred at the level of policy, research and practice (Willis, *Ibid*.). The reasons for the emphasis on gender equality are many. Over the past three decades, stakeholders involved with science education have become increasingly aware of differences in the participation and achievement of girls and boys in science (Johnstone and Dunne, 1996). Feminist critics of science argue that the power embedded in masculine discourses of science reproduce the subordination of women and that the lack of women in science is one outcome (Hughes, 2000). It is lamented that society suffers because of the lack of equality, particularly of women in science education.

The TIMSS study found that gender differences in science performance were not identified in many countries, and that the international mathematics average score for boys and girls was not significantly different (Reddy, 2006), though internationally the science average score for boys was statistically higher than for girls by six points. Yip *et al*. (2004) claim that the differential performance between boys and girls has been linked to the dominance of boys over girls in entering science courses in the higher secondary and university levels, particularly in physical sciences. They further mention that boys and girls are different in their interests and expectations from an early age, and that these gender differences may shape the children's perceptions of self-competence in various school subjects. It is also maintained that boys and girls differ in their styles of learning.

In Africa, according to Mulemwa (2004), research has shown that the patriarchal nature of African societies has led to men stereotyping the roles expected of women and girls, and to females accepting these roles. Reddy (1998) has pointed out that historically, the participation of girls in science and technology education has been poor, especially where in some parts of Africa certain racial groups and nomadic tribes were also discriminated against, resulting in poor participation in science and technology education. An important issue throughout the expansion of educational opportunities in Africa has been the under-representation of girls in the sciences (Yoloye, 1998). Jegede (1998) has pointed out that socio-cultural factors contribute to achievement and attitude differences.

In South Africa deep-seated patriarchal and sexist traditions in most cultures have combined with the inequalities of the apartheid era to deny girls and women access to educational advancement and management positions (National Committee On Further Education, 1997).

Hughes (2000) claims that over the past decade, research on gender and science education has shifted from identifying the social and institutional factors that deter girls from studying physical science to examining the part played by the science curriculum. It is now felt that providing a science curriculum that is relevant can be made to promote socio-scientific awareness of the social, political and economic dimensions to science and as well as opening up science to females and excluded or disadvantaged ethnic and class groups (Hughes, *Ibid*.). However there is the risk that the very same relevant curriculum that assists female learners could be counterproductive because this reinforces the association between males and abstract science (Hughes, *Ibid*.) – in other words a relevant curriculum might alienate the best male learners, who believe that relevant science is not real science.

2.11 THEORETICAL FRAMEWORK

As noted, this research project revolves around learners' interests in science, their performance in the preferred topics, and it also involves an investigation into gender differences regarding choices and performances. Consequently the theoretical framework used to underpin this investigation is relevance. Science education that learners experience ought to be dynamic, it ought to be linked to one's life experiences, and it ought to focus upon the world and how we take action in the world (Kyle, 1999). If the world is changing constantly, then an education in science ought to be focused upon the dynamics of change, on the whole rather than the parts, and on the ways in which individuals act in the world. Such an education would be very different from what learners experience today. Rather than focusing upon the whole, we have chosen to focus upon the parts. Seldom does an education in science focus upon action, beliefs, or interactions, all in the context of striving to change, to transform, and reinvent the world in an effort to create the future. The focus of an education in science ought to be upon an education that fosters learners' ability to work collectively toward a better society. This is quite contrary to current experiences of science learners. The science education that most learners have

experienced is bound by disciplines and is rigid, offering the impression of a static world. How can we create science that is meaningful to all learners? How do we make science more relevant? Irrelevance affects quality of life and the ability of students to control their lives (Rollnick, 1998). A consequence of irrelevance is that it stifles the economic and social potential for all the strata in our society. If science and technology education is to have an impact on improving society, relevance becomes an essential ingredient of any meaningful programme. Making science relevant is part of making the subject accessible, which leads to motivation and achievement.

Brickhouse (2003) believes that learning ought to be thought of as a process of identity formation. As learners decide what kind of person they are and what they aspire to be, they acquire what is needed through participation in relevant communities of practice.

The main concern of schools often seems to be that of learners learning decontextualised, abstract content (Kozoll and Osborne, 2004). Learning science is not merely a matter of increasing learners' knowledge of phenomena, neither that of improving commonsense reasoning. Driver, Asoko, Leach, Mortimer and Scott (1994) maintain that "learning science involves young people entering into a different way of thinking about and explaining the natural world; becoming socialized to a greater or lesser extent into the practices of the scientific community with its particular purposes, ways of seeing, and ways of supporting its knowledge claims" (p8). Science has a link to lifeworld, identity and self. The notion of identity in science should include learners' identities in their collective, inclusive of an orientation toward both who the student is and who he wants to become (Kozoll and Osborne, 2004). In Brickhouse, (2003), it is pointed out that identities are not in-born traits, identities are rather enacted. Identities speak as much to what kind of person we want to be as our own personal history

2.11.1 Lifeworld, Identity And Self

In Kozoll and Osborne (2004) it is mentioned that the science education community faces a difficult conundrum – the problem of meaning in science education. They maintain that for individual meaning to be found in science, what is needed is for the student's world and the world of science as a whole to broaden, open, and embrace one another so that the intentions of both sides can come into intimate contact and be tested. The problem is how to realise such a challenge within science education – one that "pedagogically emphasizes encountering science amid the structures, phenomena, and understandings that comprise the student's world as it is experienced while promoting encounters that open up the possibilities that exist between learners and science?" (*Ibid*., 166). Kozoll and Osborne further suggest that science instruction that starts from the learners' larger interests, concerns and ways of knowing the world allow the learners to learn science in a manner which opens up the horizons from within which science and self are understood, and contributes to the development of both (*Ibid*.). For science to have meaning for the individual, it cannot be portrayed and approached as a set of unchanging facts, laws, and theories that make up the complete natural world. If science is to have any meaning for the individual it must become one way of increasing, improving and understanding the relationship with people, nature and the world. To change science education in a manner that facilitates this requires the connections between people and place to be the starting point of scientific teaching and learning (Kozoll & Osborne, 2004). Within an overall framework of learning science by doing science it is important to have goals that are relevant and interesting to the learners. The learners need to create an identity that includes enjoyment of science and success in doing it. It is also important that science-related attitudes develop through participation in science. Tobin (2005) sees as essential the need for learners to get involved in the doing of science and building an identity in which self and science are interconnected. If most citizens need to engage science as practices in the everyday aspects of life (as distinct from engaging as scientists or in science-related professions), an initial goal in the

high schools might be to focus on success, enjoyment and active participation. Then allow those learners, whose identities connect to science, who enjoy science, to make choices about which way they wish to go (*Ibid*.).

2.12 SUMMARY OF CHAPTER

There are inequities within the global community regarding the social distribution of knowledge, and inequities also of individual access to knowledge. Social construction and distribution of knowledge is plural, there is no one or universal way of acquiring knowledge. This means that while everyone thinks, not everyone processes knowledge in the same way; each constructs meaning in the context of his/her life, and experiences. The knowledge and skills that learning activities produce are tied to the situation in which they are learned. If knowledge is not understood in the same way by all, then it stands to reason that science education experienced by learners should be dynamic, and linked to one's life world experiences, focusing on the world, and how to act in the world – the focus of science education should be on an education that encourages learners' ability to work together toward a better society. This education is in contrast to the current education that learners receive (Kyle, 1999). For many topics taught in schools researchers have uncovered a great deal of discouraging evidence showing that learners are often unable to meaningfully apply the knowledge which they acquire in school, i.e. that there is a need for scientific literacy (McGinn & Roth, 1999). This inability to apply knowledge in real-world settings has been attributed to the situated nature of knowledge. When individuals learn, they use the features of the situation in which they learn something to index the knowledge in their memories, for future access. Science education is successful only to the extent that science can find a niche in the cognitive and socio-cultural milieu of learners (Jegede, 1998). This type of school science is not currently in effect – in summary, a recurring criticism of traditional school science is its lack of relevance for the everyday world.

CHAPTER THREE – RESEARCH DESIGN AND METHODOLOGY

3.1 INTRODUCTION

The purpose of this research project is to determine what science topics in the current grade 11 curriculum learners find relevant, and how this relevance relates to performance. An inquiry is also made into gender differences in relation to understandings of relevance and related performance. The chapter outlines the methods used in trying to answer the research questions mentioned earlier. It includes a discussion on the statistical procedure followed.

3.2 CONTEXT OF RESEARCH

The context of the research study is a low socio-economic secondary school in an urban area. The learners are black African, of a fairly homogeneous group. They are bussed in from the surrounding poor areas. Many of them leave for school in the early hours of the morning, and get home in the early evening. It is not a typical South African township school, in that the classes are not unduly large in number (35 per class) and teaching/learning appears to be of a comparable level to other more privileged schools. The classes have an almost equal distribution of boys and girls. Money is a big issue for many, and most do not have access to extra learning aids and resources that learners in other schools might have. The learners are extremely enthusiastic, many of them bright and appreciative of a good education.

3.3 SAMPLE SELECTION

The choice of sample was motivated by convenience. Two classes of grade eleven learners taught by the researcher (year group 2006) were chosen for this study. The

questionnaires were administered at the end of the year when all the topics had been taught, i.e. upon completion of the syllabus. At this point it was assumed that the learners should have a fairly good idea of what topics they found relevant to their lives/experiences/potential careers, because they had been taught all the topics in the syllabus. The sample comprised two classes (making up 46 learners; equal mix of boys and girls) of learners. Some of the learners did science on the higher grade, though the majority of the learners were standard grade learners. The learners were cooperative, and no problems were encountered during the study. Since I teach these learners, there was easy access to their year-end examination scripts that were used for the comparative analysis of relevance versus performance.

3.4 DATA COLLECTION

Quantitative and qualitative methods of research have been employed to collect data in this research project. Quantitative researchers seek explanations and predictions that can be generalized to other persons and places. The intent is to establish, confirm or validate relationships and to develop generalizations that contribute to theory (Leedy, 1997). Qualitative researchers regard their research task as coming to understand and interpret how the various participants in a social setting construct the world around them (Leedy, *Ibid*.). Qualitative research can yield information that is often not available from other methods. Relevance in science education and how learners feel about relevance of science content is a rather vague and difficult area to negotiate. The use of qualitative methods of research, such as focus group discussions, could potentially yield information that might not be available from qualitative methods such as closed question questionnaires where responses could simply be tallied. Rather than sample a large number of people with the intent of making generalizations, qualitative researchers tend to select participants purposefully to learn about the range of behavior related to the research focus or in order to gain understanding of the complex phenomenon in question (Leedy, *Ibid*.). The research topic ‘relevance and performance’ is a complex topic – the nature of

which needs to be investigated using quantitative and qualitative methods. Leedy (*Ibid*.) makes the point that many research studies could be enhanced by combining both quantitative and qualitative methods. This research project utilized both methods.

3.5 QUANTITATIVE RESEARCH METHODS

The quantitative research methods used were questionnaires and document analysis.

3.5.1 Questionnaires

A questionnaire is a tool used in research to gather data. This is given to respondents to complete unsupervised by the researcher. The justification for its use is that there is no other more reliable and valid method that can be used (Opie, 2004).

The design of a questionnaire has to consider three factors: the aim of the research; the resources on hand; and the population concerned (Opie, 2004). Questionnaires can be open-ended, or contain response categories as in Likert scales. Open-ended questions have the advantage in that they do not pre-empt answers from respondents, allowing for richer and more original data. These responses can, however, be more difficult to code and analyse. Questionnaires with response categories are easily analysed, however these might bias respondents, reducing the chances of obtaining original data. A combination of open-ended and response categories in a questionnaire might thus yield more comprehensive data.

In this research project a Likert scale is used in conjunction with the questions. Likert scales are widely used in research and refer to the type of scale used in questionnaires, which while covering possible responses, also enables a degree of differentiation to be achieved between them. The data from such questions is ordinal and only provides a level of ranking. What this means is that no arithmetical analysis

between the responses is possible (Opie, 2004), and in this case, one respondent selecting 'find relevant' might well have similar ideas to another selecting 'find interesting'.

The questionnaire used in this research project comprised a list of topics that were completed in the grade eleven science curriculum in 2006, which learners used to identify sections that they found relevant. The topics included vectors, equations of motion, graphs, gas laws, solutions, chemical bonding and inorganic chemistry. Learners ranked their preferences in terms of relevance according to a Likert scale, where 'A' represented very relevant to potential career, 'B' represented relevant to day-to-day experiences, 'C' represented interesting, but not relevant and 'D' represented neither interesting nor relevant. This scale allowed for a gain of more detail regarding learners' options, as opposed to simple yes/no answers. The options ranged from 'relevant and interesting' to 'neither relevant nor interesting' (Appendix I). Every topic allowed for learners to expand on their choices (space was allowed for explanation of their choices)

The data that was obtained from this questionnaire lent itself to quantitative analysis. However there was also a qualitative aspect to this study: Research question 4 required information of a qualitative nature – i.e. it required an explanation for their choices. Reasons for choosing certain topics or not choosing topics cannot be ascertained from close-ended options in a questionnaire. Possible reasons were obtained by inclusion of space for supplying an explanation for each choice on the questionnaire (see Appendix I). In addition learners were allowed to give input on any other topics that they would find interesting. Learners were additionally asked to indicate their gender on the questionnaire, to allow for the analysis to be linked to gender.

3.5.2 The Pilot Study

A questionnaire does not emerge fully-fledged for implementation; it has to be created or adapted, fashioned and developed to maturity, i.e. it has to be piloted

(Opie, 2004). Conducting a pilot study is recommended because not only does it help with the wording of questions, it also helps with procedural matters such as the ordering of question sequences and the reduction of non-response rates (Opie, *Ibid*.).

The questionnaire was piloted to two grade 11 classes at the school in 2005. A copy of the pilot questionnaire can be found in Appendix II. This process allowed making changes which otherwise might have affected the validity and reliability of the results. Pilot studies can be used to ascertain whether respondents had difficulty with the questionnaire with respect to the language used and topics mentioned. Among the changes made as a result of the pilot study was the explanation of the word 'relevant' – this was found to be problematic. The meaning of the word was explained to the learners repeatedly, and the definition also appeared on the questionnaire for referral (see Appendix I). The explanation was that relevant meant 'relating in some way to your life/future career/interests'. Subsequent care was taken to ensure that there was clarity in their understanding, by questioning the learners about their understanding. It was also discovered that using a Likert scale would allow for richer data, with a bigger range of opinions, as opposed to the original scale that was used, which required learners to merely state whether or not they found the topic concerned relevant. Hence an adapted questionnaire was drawn up.

3.5.3 Administration of the questionnaire

The questionnaire was completed under examination conditions, i.e. there was no communication allowed during administration of the questionnaire. This took place during school hours, requiring approximately half an hour to complete.

3.5.4 Document Analysis

How does one judge whether learning has occurred? What are the means by which we can say that learners have successfully grasped a concept? Among the many

methods of assessment are tests or examinations. An examination, for example, indicates the level of achievement or performance regarding certain topics in a learning area. Are they an accurate measure of what a learner knows? Most forms of assessment are not ideal, there are very few that will fully assess all the outcomes that a teacher expects – examinations notwithstanding. Examinations are the method of assessment used by the school, and hence is the tool used in this research project to compare concepts of relevance to performance.

Unlike other methods of analysis, document analysis is not an interactive technique. Here data is collected from documents to gather insight for a particular research topic. In educational research the documents could range from syllabi, curricula, textbooks, minutes, lesson preparations, learner files, and in this case, examination scripts. Examination results are a rich repository of information on performance differences, and can provide data on teaching and learning difficulties (Lewin, 1993).

3.6 QUALITATIVE RESEARCH METHODS

The major drawback with questionnaires is that they are not good for answering the question 'Why?' Questionnaires are good at yielding information about what, where, when, and how, but not about 'why' (Opie, 2004). Open-ended questions could be set to try and achieve such exploration, but often do not succeed because many respondents are either not keen or not confident enough to express their thoughts and opinions on paper. To give research its richness and value, the findings from questionnaires need to be explored. This is much better achieved through direct communication, and for this another technique must be used (Opie, 2004). Hence the need for some form of interview.

3.6.1 Focus Group Discussions

Since part of the purpose of this investigation was to obtain insight into the views and beliefs of learners, focus group discussions were used to capture richer data. Focus group discussions allow for multiple lines of communication in quick time (Osborne & Collins, 2001), thus presenting a more time efficient strategy for data collection than individual interviews.

Focus group discussions also offer a means of exploring the principal issues of interest in a dynamic manner, which utilizes the group interaction to challenge and probe the views and positions of the individual members in a non threatening, relatively naturalized social context. The group context also offers a degree of support and security and the option not to respond, which is not available in a one to one interview. Data gathered might be more accurate since there is no compulsion to tell a 'story'. Strother (1984) believes that focus group interviews yield more accurate information about what participants really think than do other research methods. However, Azjen and Fishbein (1980) believe that there is always a gap between attitudes, actions and beliefs, and as a methodology most methods suffer from using a less natural setting than that of participant observation, where participants' actions could expose more of the views and values than at any interview. Focus group discussions could also result in individuals being unwilling to deviate from the opinions of the group. One needs to be aware of this possibility, and be prepared to intervene in case of these occurrences.

Learners were asked to volunteer for a focus group discussion, and the first eighteen to put up their hands were chosen. The size of the groups was determined on the basis that the groups should be small enough to elicit responses from all the members, yet large enough to allow for learners to feel at ease. The size of the groups also allowed for a presentation of varied responses (Osborne & Collins, 2001). The focus group discussions enriched the data gathered from the questionnaires and the year-

end examination scripts. The groups comprised six learners each – three groups were interviewed. Each group consisted of equal numbers of boys and girls. The group discussions were semi structured – with questions based on the analysis of the questionnaires and the examination scripts. Semi-structured interviews are a more flexible version of structured interviews that will allow for a depth of feeling to be ascertained by providing opportunities to probe and expand the interviewee's responses. It also allows for deviation from a prearranged text. The semi-structured interview also gives overall shape and helps to prevent aimless rambling (Opie, 2004). An interview protocol (Appendix III) was used to guide the discussion. The discussions took place in an informal setting outside in the school grounds, each lasting approximately thirty minutes.

3.7 ETHICAL CONSIDERATIONS

Ethical clearance for this study was obtained from the Gauteng Department of Education (GDE). The learners were fully informed of the purpose of the study, and their co-operation was requested. Due to the nature of this investigation where performance was tied to choices of relevance, learners were required to enter their names on the questionnaires. A big advantage in using questionnaires as an instrument is usually that it guarantees anonymity, and hence respondents feel no discomfort in answering questions. The nature of this research project however was such that the questionnaires had to be matched with the examination script. It was explained to the learners that none of the data required from them was of a sensitive nature, and it was therefore agreed, after no objections were raised that it was acceptable for them to write their names. However, in order to ascertain that there was no pressure, they were told again before the administration of the questionnaire that they were allowed the choice to omit their names if they so wished. Power relations must be acknowledged, in that the teacher taught the pupils, and they were familiar with each other. However all learners supplied their names. The following procedure was followed:

1. They were informed about the aim of the investigation.
2. They were given the option of remaining anonymous if they so wished.
3. They were informed that completion of the questionnaire was voluntary.
4. They were told that the findings of the study would be explained to them upon completion of the investigation.

3.8 DATA ANALYSIS

Data was analysed using frequency counts for both the questionnaires and the examination scripts. These were recorded on spreadsheets. For the focus group discussions, field notes were taken during the discussions.

3.8.1 Analysis of questionnaires

The questionnaire consisted of topics in the current grade eleven science curriculum, and learners were given four options (A, B, C, D) to indicate the degree of relevance and interest to themselves regarding these topics (see Appendix 1). In order to do the frequency count the option chosen by each learner for each topic was noted. These were tabulated next to each learner's name. The frequency with which each option was chosen for each topic was noted. A symbol distribution for each class was also done, which was then combined with the record of preferences to produce a composite list of results. A comparison of options chosen by boys and girls for each topic was also made. The open-ended questions were included to inform on the choices the learners made. The answers to these questions were used to interpret data yielded by the questionnaires.

3.8.2 Analysis of examination scripts

Analysis of the examination scripts also involved frequency counts. The data was captured on a spreadsheet next to each learner's name and the mark obtained for each

question was converted to a percentage and recorded in the table. Overall averages per topic were determined, as were averages obtained per topic per gender (gender analysis). These were recorded in the spreadsheets. Percentage distributions were done for each class. A composite list (for both classes) was subsequently drawn up.

In order to examine the connection between relevance and performance, the academic performance of the learners in the final physical science examination paper in grade 11 was analysed in relation to the topics appearing in the questionnaire. For example, in the physics paper, marks in the section on vectors, equations of motion and graphs were assessed in relation to each learner's rating of relevance. The percentage of the learners' performance was calculated in each section, and the symbol obtained per topic was determined. These results were then tabulated together with the learners' relevance rating as determined from the questionnaire (Tables 4.7, 4.8)

The examination question paper was set externally. The reason for this examination being set externally was that the school was chosen as a 'Dinaledi' school by the GDE. Dinaledi schools are schools that obtained more than a specified number of higher grade passes in mathematics/science in the previous school year. This status meant that all Dinaledi schools were required to write a science and mathematics examination set by the GDE. These examinations were found to be challenging by the learners, since the questioning technique was different to their experiences during the course of the year, and it was their first exposure to an external examination. The learners wrote two papers: physics and chemistry.

Multiple-choice type questions in the examination were not included in the analysis, since these types of questions involved an element of chance, thereby nullifying the intent of the analysis. In addition, it has been found that these learners habitually involve some guesswork with multiple choice type questions, and considering that the investigation dealt with actual performance, it was decided to omit these questions from the analysis.

Gender comparisons were based on the frequency counts for questionnaires and results.

3.8.3 Correlation of data

This research project revolved around determining whether there was a relationship between two variables, viz. relevance and performance. Correlation of the data was accomplished using statistical analysis, i.e. noting whether there was a correlation between the choices made on the questionnaire regarding a particular topic, and the actual percentage obtained in the same topic in the examination. Correlation analysis focuses attention on the correlation coefficient *r* obtained from the sample which can be expected to reflect the extent of agreement between values of X (relevance) and Y (performance) in the population (McCullough, 1974). Coefficients of correlation are indices of relationship. Any correlation coefficient is an index of the extent to which measurements of the same individuals are to be found on corresponding segments of two different scales. The correlation coefficient is a real number, a constant that indicates the degree of relation between two variables. When such a relationship holds precisely and with no exceptions, the correlation is said to be perfect, and the coefficient is 1.00. Less than perfect relationships produce coefficients smaller than 1.00 (Phillips, 1973). When the relation is perfect but inverse, the correlation coefficient is –1. When there is no relation whatever between the two variables, the coefficient is zero.

The statistical test used to determine correlation was the Spearman rank-difference (rho) procedure, and the Kappa-value was calculated as a measure of agreement between the variables. A statistical package was used to compute the calculations.

Tables of data containing both questionnaire data and examination data were drawn up. Data for both classes were combined into one set and statistical tests were used to

determine correlation of data. Interpretation of this data was then used to inform upon the focus group discussions.

3.8.4 Statistical Test

Spearman's Rank Order Test is a non-parametric measure of correlation – that is, it assesses how well an arbitrary function could describe the monotonic relationship between two variables. A linear relationship is required for the Pearson product-moment correlation. (McCollough, 1974). Using Spearman's rho, *r*, for Likert scales assumes that the psychologically "felt distances" between scale points i.e. ordinal scale of measure are the same for all distances between the options of the Likert scale used (*Ibid*.). This procedure places all subjects in order from smallest to largest on the basis of their scores on X; then it ascertains how nearly their Y scores approximate that order. This test determines if there is a significant monotonic relationship between two sets of ordinal scale data (this refers to measurements which are ranked).

Kappa value is a chance-corrected measure of agreement between pairs of observers. It reflects the degree of agreement for a particular physical finding. In general, a high level of agreement occurs when kappa values are above 0,5. Agreement is poor when kappa values are less than 0,3 (http://depts.washington.edu/physdx/eglossary.html)

For each of these areas the pupils' interests/relevance were assessed as A = very relevant, B = intermediate relevance and C = little relevance. The original options A, B, C and D were regrouped, whereby options A and B were combined as A (very relevant), option C became B (intermediate relevance), and option D became C (little relevance). This adjustment had to be made in order to analyse the data statistically instead of just hand counting the data as originally intended during the course of the study. The marks obtained for each pupil in these areas ranged from 0 – 100, but were categorized into three groups as <30, 30-60 and > 60 since the statistical tests required ranking of the data.

Data were entered into an Excel spreadsheet and analysed with a SAS version 9.1 statistical package. (ref SAS Institute,Inc. The REG procedure. In: SAS/STAT guide for personal computers, Version 9.1. Cary, NC:SAS Institute; 1987;773-875).

Data were analysed for the total group. For the association and correlation between relevance and marks obtained in each subject area, an exact Fisher test and Spearman correlation respectively were used. For agreement between relevance and marks, a Kappa coefficient was utilized. Furthermore, for each student, a median mark representing all the subject areas was calculated and correlated with relevance using the Spearman correlation test. In the results data are expressed as frequencies and percentages. A $p< 0.05$ was taken as a level of statistical significance.

3.8.5 Analysis of open-ended questions from questionnaire and focus group discussions

These were read through (both the transcripts of focus group discussions and the questionnaires), and were then interwoven into the results and discussion where relevant.

3.9 SUMMARY OF CHAPTER

The chapter has outlined quantitative and qualitative methods of research; their uses, and means of use with regard to this research project. Both these research methods were utilized in this research project, hence a preamble was given motivating for the uses and methods applied. Details of the statistical procedures used were also outlined.

CHAPTER FOUR – RESULTS

4.1 INTRODUCTION

This chapter presents the results of the data gathered during this investigation. The results for each of the research questions are presented in the form of a table in the order of the research questions as given in Chapter 1, page 4. The main points emerging from the data are briefly stated after the tables.

4.2 RESULTS FOR RESEARCH QUESTION 1

Research question 1: "***What science topics in the current grade eleven science curriculum do learners find relevant?"***

The data from the two classes were combined such that n = 46. Numbers were assigned to each learner in the tables, instead of using learner's names in order to comply with ethical requirements of confidentiality at the level of data presentation.

The data is presented in the form of four tables:

- Tables 4.1 and 4.2 present the responses of the learners in terms of the relevance/interest rating per topic in the grade eleven science curriculum, with Table 4.1 providing data for the females in the sample, and Table 4.2 providing that for males.
- Table 4.3 provides a total of symbols obtained for each topic.
- Table 4.4 contains a gender analysis of preferences for topics contained in the curriculum. The topics were grouped into broad categories of physics and chemistry.

Table 4.1: Data from female learners in the sample with reference to research question 1: "What science topics in the current curriculum do learners find relevant?"

Learner	Vectors	Equations of Motion	Graphs	Gas Laws	Solutions	Chemical Bonding	Inorganic Chemistry
1	C	B	A	C	B	C	B
2	C	C	D	C	B	A	B
3	D	C	D	B	D	B	B
4	C	B	B	B	B	B	A
5	C	A	D	A	C	A	-
6	C	C	D	C	C	B	C
7	C	B	C	B	C	C	B
8	D	B	A	D	A	C	A
9	D	B	C	A	A	B	A
10	D	B	C	B	B	A	A
11	D	C	B	C	A	A	A
12	C	B	B	C	C	A	C
13	C	B	B	C	C	A	A
14	B	B	D	A	C	D	A
15	D	C	C	B	D	B	A
16	D	B	D	A	A	A	A
17	D	D	B	A	D	A	A
18	C	A	A	A	B	A	A
19	D	D	C	A	A	B	A
20	C	C	B	B	A	B	C
21	C	B	C	C	D	C	A
22	C	B	B	A	B	A	A

Key: A relevant to career

B relevant to day-to-day experiences

C interesting, but not relevant

D neither interesting nor relevant

TABLE 4.2: Data from male learners in the sample with reference to research question 1: " What science topics in the current curriculum do learners find relevant?"

Learner	Vectors	Equations of motion	Graphs	Gas Laws	Solutions	Chemical bonding	Inorganic chemistry
1	B	B	C	B	B	C	B
2	C	C	C	C	C	C	C
3	C	C	D	B	B	B	B
4	B	B	C	C	C	A	D
5	B	B	C	A	A	A	A
6	C	B	B	A	B	B	B
7	B	B	A	C	C	C	B
8	C	A	D	A	B	A	A
9	B	B	B	C	D	D	D
10	B	A	A	C	B	B	B
11	B	A	D	C	C	C	C
12	A	A	B	C	C	B	B
13	D	A	B	C	D	C	D
14	B	B	C	C	B	C	D
15	C	B	B	C	A	C	D
16	C	B	C	C	C	C	D
17	D	A	B	A	C	B	B
18	D	B	B	D	C	C	B
19	B	A	C	D	B	D	D
20	C	A	A	A	A	A	A
21	B	B	B	C	B	B	B
22	B	A	A	B	D	D	C
23	B	B	B	C	C	A	A
24	A	C	A	A	A	C	*

KEY

A relevant to career

B relevant to day-to-day experiences

C interesting, but not relevant

D neither interesting nor relevant

***** option not completed by learner

Table 4.3 provides a total of symbols obtained for each topic, indicating which sections learners find most relevant. For example only 15 learners (2 learners chose option A and 13 learners chose option B) found vectors in some way relevant, while 35 learners (11 learners chose option A and 24 learners chose option B) found equations of motion relevant. Analysis by gender is dealt with in relation to Research question 4.

Table 4.3: Overall Questionnaire Data Analysis

	Vectors	**Equations of motion**	**Graphs**	**Gas Laws**	**Solutions**	**Chemical Bonding**	**Inorganic Chemistry**
A	2	11	8	14	10	15	18
B	13	24	16	9	14	13	13
C	19	9	13	20	15	14	6
D	12	2	9	3	7	4	7

N = 46

N = 44 for inorganic chemistry (two questionnaires were incomplete)

KEY

A relevant to career

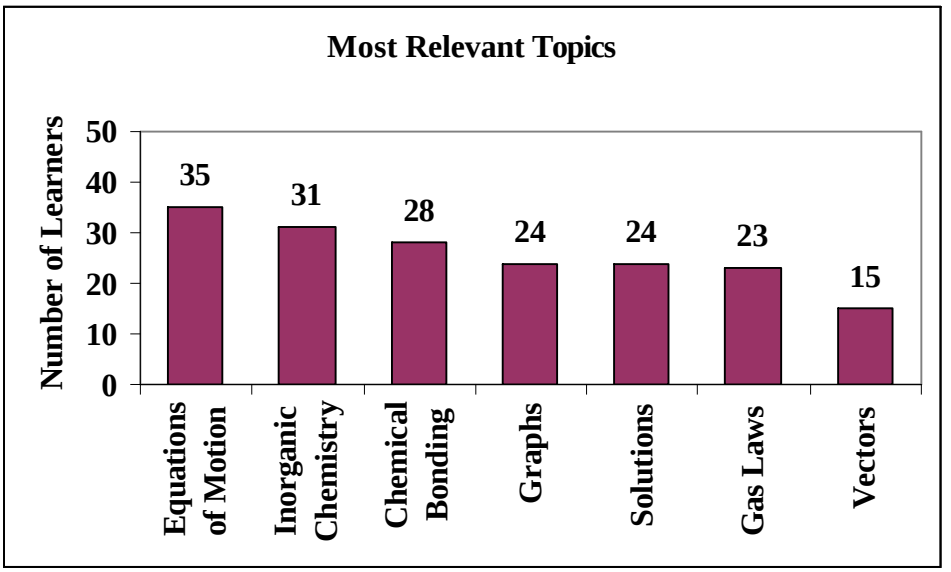
B relevant to day-to-day experiences

C interesting, but not relevant

D neither interesting nor relevant

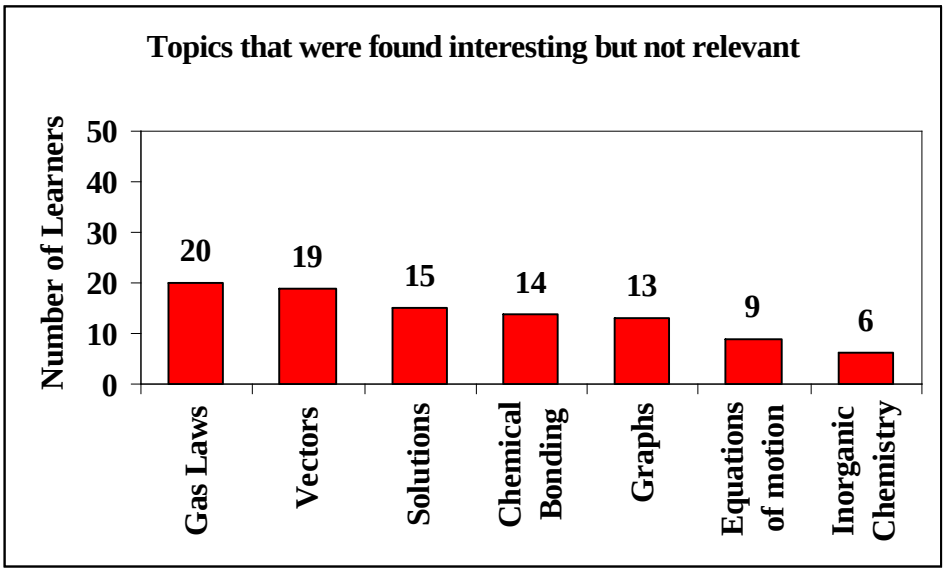
Analysis of the results showed Equations of Motion to be the most relevant topic for learners, and Vectors to be least relevant. The order of relevance is shown in the graph (Fig 1) overleaf:

Figure 1: Most Relevant Topics



The graph (Fig 2) below shows topics that were found interesting, but not relevant: (This shows the number of learners who chose option C on the questionnaire).

Figure 2: Topics found interesting but not relevant

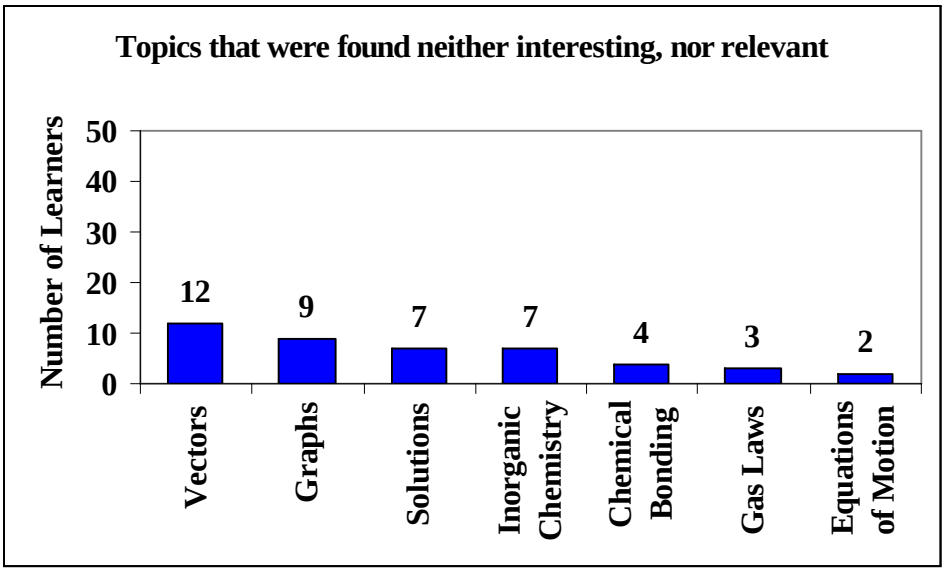


From Figs. 1 and 2 it can be seen that Vectors and Gas Laws were sections that the learners found least relevant, yet these were also found to be listed as the most interesting sections (see graph). The same applies to Equations of Motion and Inorganic Chemistry – these were found to be the most relevant, yet the least interesting.

Note: Graphs is a topic that was taught to all the learners, hence the inclusion of this topic in the questionnaire on relevant content. This topic was not part of the standard grade curriculum however, and hence was not examined in the standard grade year-end examination.

The graph below (Fig 3) shows topics that were found neither interesting, nor relevant, in decreasing order (option D on the questionnaire).

Figure 3: Topics that were found neither interesting nor relevant



The analysis of data in relation to Research Question 1 indicates that most (35/46) learners found the section on equations of motion the most relevant. Very few found

this section neither interesting nor relevant (Only 2/46 chose option D for this topic). The topic found most irrelevant was vectors, yet many did find the section interesting – in fact more learners found it interesting rather than relevant.

A chemistry section that proved popular in terms of relevance (the second most chosen topic in the relevant category) was inorganic chemistry.
Another chemistry section that proved popular was Gas Laws, more in terms of interest than relevance. Many showed interest regarding gas laws (20/46 chose option C). The sections on Graphs, Solutions and Chemical Bonding showed very similar ratings by the learners, viz. they were thought almost equally relevant, and interesting, while an almost identical number of learners found these topics neither relevant nor interesting.

It appears from this analysis of the data that there was little in the science curriculum that the learners found uninteresting or irrelevant – the results indicate rather that they found topics either interesting or relevant. The option 'D' was chosen fewer times than any other option. It would appear, by and large, that learners were either interested in topics or found topics relevant to their contexts.

4.3 RESULTS FOR RESEARCH QUESTION 2:

Research question 2: "***Which topics are linked to poor performance?"***

The purpose of this question was to establish which topics learners managed well in terms of assessment, as well as to identify the sections in which learners performed poorly. The data for this question are provided in tables 4.4 – 4.5. Examination scripts were analysed by topic and by gender. The results for each topic are given as a percentage for the purpose of easy comparison. Table 4.4 shows the examination results of female learners in the examination, and Table 4.5 shows the examination results of the males. Table 4.6 shows an overview – males and females - of the

results obtained in tables 4.4-4.5, to give a summary of the performance in each section of the sample as a whole.

Table 4.4: The results by topic of female learners in the examination

Learner.	Vectors %	Equations of Motion %	Graphs %	Gas Laws %	Solutions %	Chemical Bonding %	Inorganic Chemistry %
1	20	31	*	80	66	42	36
2	22	38	*	67	67	75	36
3	2	52	*	47	50	42	29
4	47	73	78	88	0	100	45
5	0	0	*	53	33	33	0
6	10	45	*	73	66	0	11
7	18	21	*	60	50	0	29
8	26	55	*	87	50	25	33
9	38	64	75	50	45	17	46
10	22	59	*	40	67	42	29
11	28	52	*	60	67	58	25
12	58	27	59	50	18	50	30
13	0	21	*	31	66	33	27
14	4	31	*	16	50	42	15
15	14	55	*	47	50	100	20
16	24	76	*	100	67	58	47
17	0	10	*	27	17	33	25
18	20	59	*	60	0	50	35
19	8	14	*	40	66	42	22
20	2	28	*	40	67	50	11
21	12	31	*	47	10	0	18
22	38	61	69	44	45	92	52

*Only higher grade learners did the questions on graphs. Those marked with * indicate standard grade learners.

Table 4.5: The results by topic of male learners in the examination

Learner	Vectors %	Equations of motion %	Graphs %	Gas Laws %	Solutions %	Chemical bonding %	Inorganic chemistry %
1	18	48	*	53	50	33	20
2	24	3	*	47	50	8	18
3	64	88	84	19	83	83	56
4	62	61	6	56	0	0	27
5	36	45	41	25	27	58	41
6	16	48	*	53	50	17	22
7	10	17	*	60	33	67	9
8	29	45	9	19	0	0	37
9	12	69	*	73	33	33	5
10	32	76	*	73	50	67	27
11	14	28	*	67	67	92	38
12	34	59	*	53	50	33	16
13	67	73	6	38	0	67	38
14	16	76	*	60	0	33	31
15	12	69	*	60	17	58	18
16	58	76	88	63	45	75	42
17	0	62	*	53	0	17	47
18	27	27	28	31	45	100	45
19	60	61	0	53	33	50	31
20	8	62	*	53	17	75	16
21	8	0	*	20	0	33	36
22	47	48	25	69	0	67	34
23	44	42	6	25	18	8	34
24	4	31	*	47	50	33	20

* Only higher grade learners did the question on graphs. Those marked with * indicate standard grade learners.

Table 4.6: Summary of the examination results (males and females)

Percentages	Vectors	Equations of motion	Graphs	Gas Laws	Solutions	Chemical Bonding	Inorganic Chemistry
>80%	0	1	2	4	1	6	0
70-79%	0	6	2	3	0	3	0
60-69%	4	8	1	10	10	4	0
50-59%	2	7	1	10	11	8	2
40-49%	3	7	1	9	4	5	7
33-39%	4	1	0	1	4	9	10
<33%	33	16	7	9	16	11	27

N = 46

N = 14 for graphs (higher grade only)

Analysis of the data yielded information regarding how learners performed in each topic in terms of average percentages obtained and failure rate. These indicators appear in the graphs below (fig 4 and 5).

Figure 4: Performance in topics (in descending order):

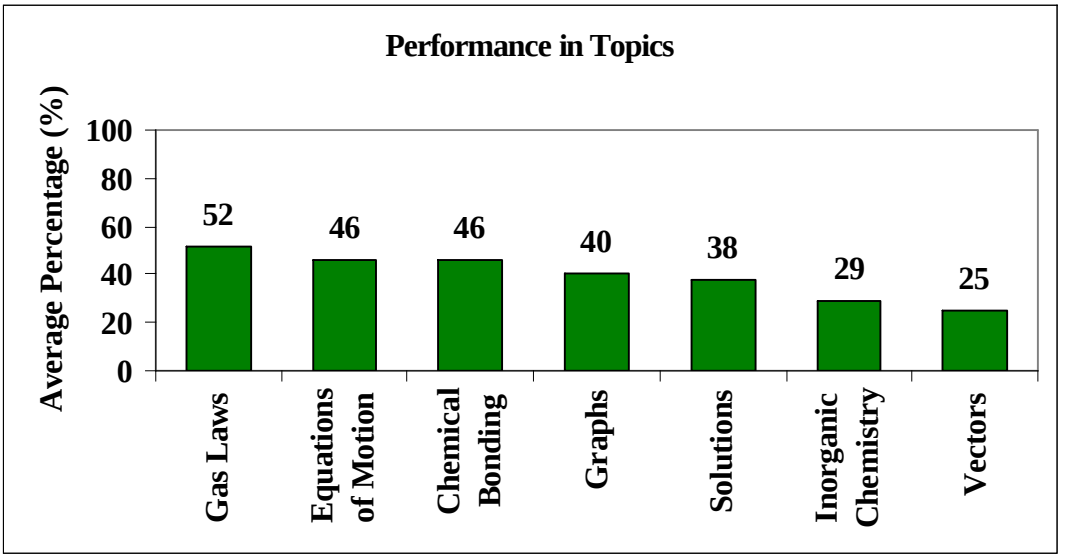
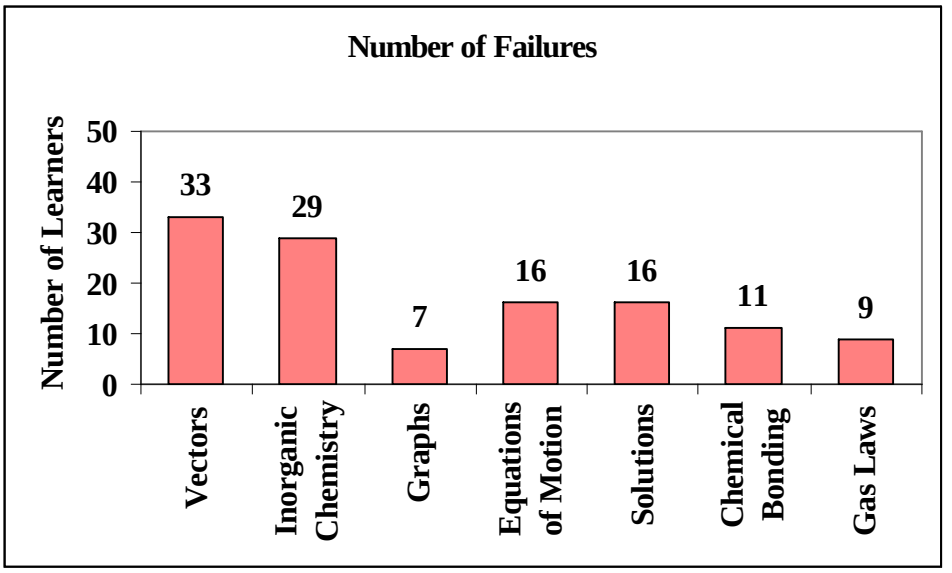


Figure 5: Number of Failures



Only the higher grade learners answered the question on graphs with the result that it is not possible to comment on graphs in the same way as the other topics, beyond the observation that graphs were found difficult by learners, to the extent that they were not tackled by those on the standard grade. Learners fared in a very average manner in the section on solutions, where 65% passed and 35% failed.

The overall performance of the learners was poor. As can be seen from the Fig 5, learners performed best in the section on Gas Laws where there were only 9 failures and the average percentage was highest (fig4). The section on Equations of Motion was also answered well, as was Chemical Bonding, which had the second highest average percentage, though there was a 35% failure rate (11 failures). The section on vectors appears to be the one where learners fared worst, with a 25% average and a failure rate of 72%. Learners also performed very poorly in the section on inorganic chemistry, and there were a large number of failures, i.e. 63% (29 failures).

4.4 RESULTS FOR RESEARCH QUESTION 3

Research Question 3: "***Is there a relationship between what learners see as relevant and their actual performance in these topics?"***

This research question brings the first and second research questions together. It attempts to shed some light on the notion of a connection between relevance and performance. The tables provided in this section contain a comparison of the actual examination performance, and their relevance rating from the questionnaires, with Table 4.7 giving the results for girls and Table 4.8 giving the results for boys. It should be recalled that only the higher grade learners answered questions on graphs.
The aim of this analysis was to determine the existence of a relationship between relevance and performance. The indicator of performance rating is the average percentage and the number of passes/failures per topic. It can be seen from Table 4.8 that performances were poor and averages were low. The number of learners failing per topic was also high.
The tables appear overleaf.

Table 4.7: Comparison of questionnaire data and exam results – females

Learner	Vectors		Equations Motion		Graph		Gas Laws		Solutions		Chemical Bonding		Inorg Chem	
	E	Q	E	Q	E	Q	E	Q	E	Q	E	Q	E	Q
1.	20	C	31	B			80	C	66	B	42	C	36	B
2	22	C	38	C			67	C	67	B	75	A	36	B
3	2	D	52	C			47	B	50	D	42	B	29	B
4.	47	C	73	B	78	B	88	B	0	B	100	B	45	A
5	0	C	0	A			53	A	33	C	33	A	0	*
6	10	C	45	C			73	C	66	C	0	B	11	C
7	18	C	21	B			60	B	50	C	0	C	29	B
8	26	D	55	B			87	D	50	A	25	C	33	A
9	38	D	64	B	75	C	50	A	45	A	17	B	46	A
1.0	22	D	59	B			40	B	67	B	42	A	29	A
11	28	D	52	C			60	C	67	A	58	A	25	A
12	58	C	27	B	59	B	50	C	18	C	50	A	30	C
13	0	C	21	B			31	C	66	C	33	A	27	A
14.	4	B	31	B			16	A	50	C	42	D	15	A
15.	14	D	55	C			47	B	50	D	100	B	20	A
16	24	D	76	B			100	A	67	A	58	A	47	A
17	0	D	10	D			27	A	17	D	33	A	25	A
18	20	C	59	A			60	A	0	B	50	A	35	A
19	8	D	14	D			40	A	66	A	42	B	22	A
20	2	C	28	C			40	B	67	A	50	B	11	C
21	12	C	31	B			47	C	10	D	0	C	18	A
22	38	C	61	B	69	*	44	A	45	B	92	A	52	A

*** Option not completed by learner**

Key: E – Exam %, Q - Questionnaire

Table 4.8: Comparison of questionnaire data and exam results – males

Learner	Vectors		Equations of motion		Graphs		Gas Laws		Solution		Chemical bonding		Inorganic chemistry	
	E	Q	E	Q	E	Q	E	Q	E	Q	E	Q	E	Q
1	18	B	48	B			53	B	50	B	33	C	20	B
2	24	C	3	C			47	C	50	C	8	C	18	C
3	64	C	88	C	84	D	19	B	83	B	83	B	56	B
4	62	B	61	B	6	C	56	C	0	C	0	A	27	D
5	36	B	45	B	41	C	25	A	27	A	58	A	41	A
6	16	C	48	B			53	B	50	B	17	B	22	B
7	10	B	17	B			60	C	33	C	67	C	9	B
8	29	C	45	A	9	D	19	A	0	B	0	A	37	A
9	12	B	69	B			73	C	33	D	33	D	5	D
10	32	B	76	A			73	C	50	B	67	B	27	B
11	14	B	28	A			67	C	67	C	92	C	38	C
12	34	A	59	A			53	C	50	C	33	B	16	B
13	67	D	73	A	6	B	38	C	0	D	67	C	38	D
14	16	B	76	B			60	C	0	B	33	C	31	D
15	12	C	69	B			60	C	17	A	58	C	18	D
16	58	C	76	B	88	C	63	C	45	C	75	C	42	D
17	0	D	62	A			53	A	0	C	17	B	47	B
18	27	D	27	B	28	B	31	D	45	C	100	C	45	B
19	60	B	61	A	0	C	53	D	33	B	50	D	31	D
20	8	C	62	A			53	A	17	A	75	A	16	A
21	8	B	0	B			20	C	0	B	33	B	36	B
22	47	B	48	A	25	A	69	B	0	D	67	D	34	C
23	44	B	42	B	6	B	25	C	18	C	8	A	34	A
24	4	A	31	C			47	A	50	A	33	C	20	*

*** Option not completed by learner**

Key: E – Exam %; Q - Questionnaire

An examination of the information gathered in the two previous tables, indicates the following:

(i) More learners found the section on vectors irrelevant (more C and D options), and a low average percentage was obtained.

(ii) Many learners found the section on equations of motion relevant (many A and B options), and a high average percentage was obtained.

(iii) Learners found the section on inorganic chemistry relevant, yet results showed very poor performances (large number of failures) in this section;

(iv) Learners found the section on Gas Laws not very relevant, yet performed well in this section.

Points (i) and (ii) suggested some kind of relationship between relevance and performance. However, although most learners expressed opinions that agreed with performance, these were general results. These results did not indicate a one-to-one relationship, i.e. the results do not indicate that learners who thought a topic was relevant were the same learners who did well in that topic. It might well have been that a learner who thought that vectors was relevant did poorly in the examination. A statistical test was needed to identify a one-to-one relationship between relevance and performance. Spearman's Rank Order Test, which is a measure of correlation was used for this purpose. Correlation analysis focuses attention on the correlation coefficient *r* that can be expected to reflect the extent of agreement between two variables. To enable this statistical analysis, options A (relevant to career) and option B (relevant to day-to-day experiences) were combined, since both these options relate to relevance. A practical consideration, and one that drove the decision to combine options A and B was that the statistical analysis required one option for relevance (Likert scale utilizes decreasing/increasing order of preference). Hence option A and B were relisted as option A. Option C became option B, and option D was relisted as option C.

A summary of statistics for each of the 7 topics is presented in Appendix V. The p-values, kappa value (K) and correlation coefficient (r) appear in each table.

The probability value (p-value) obtained for each statistical test is a measure of evidence against the null hypothesis (i.e. no monotonic relationship between variables). A small p-value provides evidence against the null hypothesis, thus the null hypothesis is rejected when the p-value is sufficiently small. Convention has it that a p-value of 0,05 or below is accepted as being statistically significant. This

implies that p values greater than 0,05 correspond to statistically insignificant results. (McCullough,1974)).

The kappa-value (*K*) obtained for each statistical test is an agreement coefficient, indicating agreement between the variables. It has a maximum value of 1,00 when agreement is perfect. A value of zero indicates no agreement better than chance, and negative values show worse than chance agreement (McCollough, 1974).

The correlation coefficient *r* indicates whether the two variables are associated, that is if the values of one variable tend to be higher (or alternatively, lower) for higher values of the other variable. The correlation coefficient r measures the degree of 'straight-line' association between the values of the two variables. A correlation of zero indicates that there is no linear relation between the values of the two variables. A value of +1 or –1 indicates if all the points in a scatter diagram lie on a perfect straight line (McCollough, 1974).
A summary of the statistical analysis done using a statistical package is provided in Appendix V

Analysis of the statistics show that the p- value is greater then 0,05, which is not statistically significant. The kappa value (K) is negative, and the correlation coefficient (r) is very low – almost zero, indicating very little correlation.

An overall correlation coefficient of –0,13, and a p-value of 0,39 were obtained. This suggests no association or agreement between relevance and performance (marks) for any of the variables assessed for the whole group. The p-values were all greater than 0,05, and kappa values were all either negative or very small (tending to zero).

4.5 RESEARCH QUESTION 4

Research question 4: "***Are there gender differences with regard to research questions 1 and 2?"***

The results for research question one and two have already been presented, separated into gender, and the brief analyses have indicated overall trends. In answering this research question the specific focus of attention relates to gender differences and similarities.

The analysis of the data relevant to this for this research is provided in tables 4.4, 4.5, 4.9, 4.10 and 4.11. Tables 4.4–4.5 provide data showing the performance of boys and girls in the examination. These tables appear in the previous sections, since the data for this research question overlaps with research questions 1 and 2.

Table 4.9 provides a gender analysis of examination results.

Table 4.10 contains a gender analysis of the questionnaires, grouping the data into broad categories of physics and chemistry. Physics comprises the topics vectors, equations of motion and graphs, and Chemistry comprises the topics gas laws, solutions, chemical bonding and inorganic chemistry.

Table 4.11 provides a summary presentation of performance of boys/girls in the examination in each topic.

Table 4.9: Gender Analysis of Examination Results (average percentage per topic)

Average percentage	Vectors	Equations of motion	Graphs	Gas Laws	Solutions	Chemical Bonding	Inorganic Chemistry
Boys	32%	51%	27%	49%	32%	46%	29%
Girls	19%	41%	71%	57%	47%	48%	29%

.

TABLE 4.10: Gender Analysis of Questionnaires

Physics		*Chemistry*	
Number of Girls per option	**Number of Boys per option**	**Number of Girls per option**	**Number of Boys per option**
A 5	A 16	A 37	A 19
B 17	B 33	B 23	B 26
C 24	C 16	C 20	C 35
D 17	D 6	D 6	D 15

Key: A relevant to career

B relevant to day-to-day experiences

C interesting, but not relevant

D neither interesting nor relevant

Table 4.11: Gender Analysis of examination results (further analysis)

Percentages	**Vectors**		**Equations of motion**		**Graphs**		**Gas Laws**		**Solutions**		**Chemical Bonding**		**Inorganic Chemistry**	
	B	**G**	**B**	**G**	**B**	**G**	**B**	**G**	**B**	**G**	**B**	**G**	**B**	**G**
>80%	0	0	1	0	2	0	0	4	1	0	3	3	0	0
70-79%	0	0	4	2	0	2	2	1	0	0	2	1	0	0
60-69%	4	0	6	2	0	1	6	4	1	9	4	0	0	0
50-59%	1	1	1	6	0	1	7	3	6	5	3	5	1	1
40-49%	2	1	6	1	1	0	2	7	2	2	0	5	4	3
33-39%	2	2	0	1	0	0	1	0	3	1	6	3	6	4
<33%	15	18	6	10	7	0	6	3	11	5	6	5	13	14

Boys N = 24 , Girls N = 22 **For Graphs: Boys N = 10, Girls N = 4**

4.5.1 Summary of Analysis: Relevance

Boys showed a greater affinity for physics than girls. 69% of the 'A' and 'B' options (Table 4.10, 49/71 options) for physics topics were chosen by boys and only 31% was chosen by girls. In a similar vein, 74% of the 'D' option for physics topics was chosen by girls as opposed to 26% chosen by boys; i.e. more girls found physics topics neither interesting nor relevant.

Using the data in Table 4.10, it was found that 59% (60/102) of the 'A' and 'B' options for chemistry topics were chosen by girls, whereas 40% of these were chosen by boys. Chemistry topics seem to offer more relevance to the girls than the boys, though the difference is not as large for chemistry as it was for physics. 71% (15/21) of the 'D' option was chosen by boys, indicating that many more boys thought chemistry topics were neither interesting nor relevant.

4.5.2 Performance

When taking into account the overall performance of boys and girls in physical science (physics and chemistry together) in this sample it was found that there is little difference in performance. The average percentage in the physical science examination for boys and girls was as follows: Boys-38%; Girls-46%. However if the section on graphs is discounted (since only the higher grade learners answered this section), then the overall average percentage is: Boys-40%; Girls–40% indicating no difference between boys and girls. This information shows that in this particular school, there is no difference in the performances of boys and girls in science. (More boys than girls did science on the higher grade, however in the section on graphs, which was answered only by the higher grade learners, although the girls were fewer in number, they outperformed the boys.)

The data in Table 4.9 shows that boys outperformed girls in physics, barring the section on graphs – where the girls (four girls on higher grade) obtained 71% average. In the chemistry sections, the girls did better than the boys, though in two topics, chemical bonding and inorganic chemistry, the performances were almost identical.

It appears that boys find physics more relevant, and perform better than girls in physics. Girls found chemistry more relevant, and they also performed slightly better in chemistry.

4.6 RESEARCH QUESTION 5

Research question five: ***What explanations do learners give for their choices?***

The explanations for learners' choices are obtained from the open-ended questions in the questionnaire (appendix 1), and from focus group discussions. A copy of a transcript of part of the focus group discussion can be found in appendix IV. A selection of common explanations (as they appear on the questionnaires) are provided below: (g) = girl (b) = boy

Vectors	-	"difficult and confusing" (g)
	-	"hard to understand (b)
	-	"too challenging" (g)
	-	"too much work and very complicated" (b)
Equations of Motion	-	"easy and can be remembered" (b)
	-	"understood them perfectly" (b)
	-	"not a lot of twists" (g)
	-	"simple" (g)
Graphs of Motion	-	"easy to practice" (b)

	-	"enjoy calculations" (b)
	-	"always hated graphs" (g)
	-	"relates to equations of motion so it is easy" (b)
Gas Laws	-	"I hate chemistry!" (b)
	-	"not confusing, interesting to understand" (g)
	-	"has no impact in my life" (b)
	-	"easy to learn but I don't think I will really use it in later life" (b)
Solutions	-	"the easy part of chemistry" (b)
	-	"very much better and simpler than vectors" (g)
	-	"enjoyed it, nothing complicated" (g)
	-	"I love solutions because they involve calculations" (b)
Equilibrium	-	"Interesting, but not part of my future plans" (b)
	-	"some parts confusing" (g)
	-	"tricky and I got lost" (b)
	-	"was not one of my favourites" (b)
Chemical Bonding	-	"I love chemistry" (g)
	-	"Understand it and like it" (g)
	-	"interesting and enjoyable" (g)
	-	"easy work but too many equations" (b)
Inorganic chemistry	-	"took long to understand" (b)
	-	"very interesting and I understand" (g)
	-	"too many things to remember!" (b)
	-	"I love chemistry" (g)

These responses enhance the data provided by the questionnaires on what topics learners preferred. The varied comments indicate the wide variety of student responses to the topics. The physics topics seemed to generate similar responses from boys and girls in that the most common responses indicated dislike of the section on vectors, and a liking for the topic of equations of motion. These comments echo the findings from questionnaires. It would appear that overall chemistry was more "likeable" for girls than physics. No real information was forthcoming as to exactly what caused the enjoyment/dislike other than that the content was interesting or confusing. The topics were supposed to have been chosen on the basis of whether the content was relevant or not. However, the responses seemed to indicate that their understanding of choosing the topics related to whether they liked the topics or not.

4.7 SUMMARY OF CHAPTER

The analysis of the questionnaire data revealed that learners found the section on equations of motion the most relevant, and vectors least relevant. The chemistry section on inorganic chemistry was the most (see graph) relevant to learners. Learners' explanations for their choices were many, but did not really indicate why they found the sections relevant, other than that they were easy or confusing or interesting. Gender preferences indicated that girls found chemistry topics more relevant, and that boys found physics topics more relevant. Analysis of the examination scripts indicates that learners performed best in Gas Laws, and worst in Vectors. Again gender discrepancies arose in that boys fared better in physics, and girls did better in chemistry. However, the overall performance in physical science (physics and chemistry combined) showed no real difference in performance. Statistical correlation of relevance and performance, i.e. correlation of topics that learners found relevant, and actual performance in the same topics, showed no relationship. The correlation coefficient was very low, tending almost to zero, indicating no association between relevance and performance.

CHAPTER FIVE – DISCUSSION

5.1 INTRODUCTION

The chapter entails an interpretation and discussion of the data presented in the previous chapter. While the essence of the investigation was to determine whether or not a connection could be found between relevance and performance in the chosen sample, gender differences were also investigated. The format of the discussion in this chapter is in accordance with the research questions. Discussion related to Research Question 5 ("What explanations do learners offer for their choices?") is woven into the discussion of the first four research questions. Limitations of the methodology that might have affected the study also form part of the discussion.

5.2 INTERPRETATION OF RESULTS

5.2.1 Research Question 1: What science topics in the current grade 11 science curriculum do learners find most relevant?

Learners described 'relevant' as "applicable to what is around you" during group discussions. Many thought that the science curriculum as a whole was not very relevant to them, and believed that their performance would improve if content was more relevant to their lives. Despite further probing during the focus group discussions, not much was forthcomimg from the learners regarding what kind of content they found relevant, except for a few comments like "how to fix a TV". The responses to the open-ended questions in the questionnaires also gave no insight into their thoughts as to what constituted relevant content to them.

However, as far as relevant topics in the curriculum are concerned, learners claimed Equations of motion to be the most relevant topic in the grade eleven science curriculum. This is a sentiment that I would have predicted judging by their attitudes

in class when I was teaching the section. Learners mentioned that they found this topic relating to their daily experiences, hence their interest in this section. Perhaps they just experienced it as a much easier section than vectors, which preceded the section. It is possible that the learners misunderstood 'relevant' and took it to mean 'easy'. This dilemma, of the meaning of 'easy' versus 'relevant', was posed to them during focus group discussions, and it appeared that the distinction between relevant and easy was indeed blurred. Jenkins (2006) reports the unsurprising results of a study where there was a strong correlation between the perceived ease of a subject and learners' enjoyment of it.

Inorganic chemistry was chosen as the second most 'relevant' topic, after equations of motion. Thirty-one learners thought it relevant in some way, with only seven showing no interest in it all. This section entailed a reasonable amount of practical work, learners were exposed to a fair amount of chemical reactions (practical work) and to connections with day-to-day life, and perhaps this added to their high rating of this topic in terms of relevance. In addition this section only contained theory, no calculations at all, which might have led the learners to believe that this was an easy section.

The sections on graphs, gas laws and solutions showed an equal split among learners between those who thought these topics relevant and those who did not. For example, twenty-three learners found gas laws relevant in some way, while twenty-three did not. These topics covered content that consisted of some theory and some calculations. This combination might explain the fact that this topic showed average results in the examination.

The topic Vectors was clearly the topic thought least relevant by learners. This is the first topic that learners encounter in grade eleven, and perhaps this is why the learners found it difficult. In addition, this topic does not really relate to any prior topics that learners encountered in previous grades, so learners find it difficult to relate to.

Added to this is the fact that vector content can be difficult, with questions becoming quite complex. Vector questions often entail calculations involving complex algebra or trigonometry, and many learners struggle with these concepts. I was not sure, when learners indicated on the questionnaire that they found it 'very irrelevant', if they were not simply referring to the fact that they just found it unpleasant because it was a difficult section. Many of them did indicate, though, that they found it 'interesting but not very relevant'. Of all the topics, the most number of 'D' options (neither relevant, nor interesting) on the questionnaires hailed from the vectors section. Yet focus group discussions revealed that learners preferred calculations to content, which contrasted with the fact that questions on Vectors, which consisted of mainly calculations were answered very poorly (low pass rate).

Gender analyses showed that girls preferred chemistry topics and boys preferred physics topics. This is in agreement with literature, for example Osborne and Collins (2001) mention that school science lacks appeal for girls

5.2.2 Research Question 2: Which topics are responsible for poor performance?

Learners' performance in the science examination was poor (the average was not a pass average). Poor performances can occur due to a variety of factors. The learners mentioned the following factors that they thought impacted on their performances or on their learning :

- Relationship with the teacher
- Mental attitude
- Time
- Training from an early age
- Understanding

Learners thought that a good relationship with a teacher impacted significantly on how well they performed. They also maintained that mental attitude was a key factor

to good performance. Time was a constraint for these learners since they hail from poor socio-economic backgrounds, waking up early to get transport, getting home late, and having to do household chores and babysitting, cooking and only then settling down to school work. They also insisted that the training they received in the lower grades did not prepare them for the level of work at the higher grades, stating that content in junior high was very 'watered down' compared to the 'hard work' in the upper grades – they thought the type of work in the junior high should be upgraded.

Another explanation for their particularly poor performance in the examination could be that this was an 'external' examination – since the school is a Dinaledi school, and all such schools wrote a common examination. It was the first time that the learners wrote an external examination, and perhaps they were not used to the different questioning technique. Nevertheless, though the performances were poor, the results did follow the general trend of performance throughout the year, in that performances were always poor in the same topics, and good in the same sections.

The two sections that proved most challenging for the learners as measured by the results, were the first (vectors) and the last (inorganic chemistry) sections that were taught during the year. It may be that the first section was found to be difficult as it fell during the start up phase of school when learners were faced by all sorts of challenges at school and were in the process of settling down, while the last section might have been hurried without sufficient time for revision.

As noted, learners insisted during focus group discussions that they preferred sections that contained more calculation than theory, which might explain their poor performance in inorganic chemistry, but which makes little sense considering their poor performance in vectors, which is a topic based on calculations. Consequently there is an apparent contradiction in learners' thoughts on calculations. Most insist that they prefer calculations to theory, yet often their performance in the calculations

is not good. It might be that for these second language learners, calculations appear simpler, in terms of formulae and substitution, in comparison to learning the content with its scientific jargon. However the type of calculation questions that they encounter in the examination/tests are complex, which could also be responsible for poor marks. Furthermore, data indicated that they thought the section on vectors was interesting, if not relevant, yet they performed poorly in the examination. The only topic where learners fared well was equations of motion. The results obtained in most other topics were mediocre.

None of the learners mentioned 'relevant curriculum' as a factor that might improve performance, though the factors 'mental attitude' and 'understanding' might be seen to relate to relevance in that a relevant curriculum could increase understanding and hence also improve mental attitude. When the idea was put to them that perhaps a relevant curriculum might assist performance, a fair amount of enthusiasm was shown.

5.2.3 Research Question 3: Is there a relationship between what learners see as relevant and their actual performance in the examination?

The statistical analysis that was carried out indicates that there was no correlation between relevance and performance. This finding is in contrast to current thinking and ideologies, where the concept of relevance and the linking of content to everyday life is the emphasis in many discussions and debates on what is important in science education. For example, Osborne (2003) bemoans the fact that current science education is inappropriate to the needs and interests of pupils. He insists that to continue with a curriculum that learners find neither relevant, nor interesting is a "culturally bankrupt policy" for science. This, he suggests, is because it renders the subject remote, inaccessible and alienating, making it less likely that learners will pursue further study of science beyond that which they have to. The finding in this

study (albeit a small-scale study) appears to question Osborne's view, and that of others who promote relevancy.

When asked about what factors they thought would improve performance, none of the learners mentioned relevant content. When it was suggested to them though, they agreed that relevant content would make a difference to their performance in science. As already noted, one learner stated "for example it would be nice to know how the TV works". When asked about changes they would make to the current curriculum, they listed introducing practical applications to day-to-day life as one of the changes they would introduce. Osborne (2003) also questions the fact that despite all the technological artifacts around them, (and he notes that learners do not differentiate between science and technology) there are no explanations of mobile phones, digital imaging and other technologies that permeate learners' daily lives, in the curriculum. Sjoberg (1996), a great proponent of relevant science education, firmly believes that science curricula should be meaningful, relevant and adapted to different groups and cultures. Many educationalists argue that children would learn better if the subject matter they were being taught was embedded in the thinking of the everyday world rather than being abstracted from it. Unfortunately some research results have not been entirely supportive of this (Bennett, 1999). The findings in this study seem to echo this.

Bennett (*Ibid*.) noted the findings of two studies based on a comparison of performance of learners following the 'traditional' science courses at school, and those following a 'context-based approach'. Key findings to emerge from this study were (1) there were no significant differences in understandings between the two groups, (2) common areas of difficulty emerged, e.g. ionic bonding. Bennett found that the studies suggested a worrying number of ideas that were poorly grasped by pupils, irrespective of which approach was followed. These findings also seem to reflect the findings in this research project.

The reasons suggested for the non-relationship between relevance and performance is varied. Aikenhead (2006) mentions that learners' views on relevancy of everyday experiences do not match their teachers' views on relevancy. Jenkins (2006) provides a similar sentiment, stating that relevance has usually been defined with the interests of adults, rather than young people, in mind. This could be applicable in this study as well. Jenkins *(Ibid*.) also mentioned that everyday contexts alone did not necessarily nurture greater science attainment; neither was any harm done. I would agree with this sentiment. Relevant content might well be a contributing factor towards improved performance in science, but there are other, if not more then equally, pertinent factors that affect performance.

Van den Akker (1998) notes that achievement in science at all age levels appears to be influenced primarily by (1) the status and educational resources at home, (2) the aptitude, prior learning and gender of the student, (3) the attitudes and values towards science held by the student and (4) the motivation of the student. In other words while relevance might be a factor to consider regarding ways to improve performance, there seem to be other factors that also impact on performance. Learners also mentioned during group discussions that too much content covered in too short a time affected their performance. Osborne and Collins (2001) point out a similar concern, that of the "rushed curriculum", whereby learners speed through the scientific landscape, with barely a moment to breathe, or to absorb that which was just taught. The amount of time spent (class time and number of science courses taken) is also a factor that van den Akker (1998) noted as affecting performance in science. An analogy to the aforementioned issue, ie. that other factors over and above relevance might influence performance more is the factors that affect the growth of a plant. While fertilizer might well improve growth, it would not make much of a difference to the plant if it was planted in the wrong area, or if it was kept too dry/moist. Sunshine and a dry area might be what the plant primarily needs, and fertilizer would improve growth only if these conditions occurred. Similarly, while relevant content can make a difference, this might only happen if the learner was

innately motivated, or possessed a work ethic or spent more time on the subject to begin with.

Loveless (http://www.usatoday.com, 2006) mentioned that "happiness in mathematics classes doesn't add up". His theory based on the TIMSS 2003 report states that efforts to make mathematics relevant do not work, and that nations that try to teach mathematics in terms of daily life have the lowest test scores. He further believes that pleasing learners comes at the expense of mastering skills. In an international mathematics/science study in 2003 (TIMSS, 2003), grade 4 and grade 8 pupils across the globe were asked whether they enjoyed mathematics, and whether they did well in it. A common pattern emerged from the comparison: the ten nations whose pupils enjoyed mathematics the most all scored below average. Internationally, 29% of the learners indicated that they enjoyed mathematics. South was among the countries where the highest number of learners indicated that they enjoyed mathematics (56%) and science and yet the performance is very low (Reddy, 1996). The bottom ten nations on the enjoyment scale (like Japan, Hong Kong, Netherlands) all excelled. Loveless (*Ibid.*) goes as far as stating that the "happiness" factor should be rethought – for example in the US mathematics textbooks tend to have colourful pictures, stories, charts, to please the pupils, yet other countries where texts have strictly mathematics tend to do better.

5.2.4 Research Question 4: Are there gender differences with regard to research questions 1 and2?

Much has been said about gender issues in science education. In Africa currently, as in much of the western world, girls were found to be under-represented in the science fields, especially higher up at senior levels (Reddy, 1998). When questioned about who they thought performed better in science, almost all the learners (boys and girls) who participated in the focus group discussion, thought that boys were better at science than girls. In the current study no overall difference has been found that can be linked to gender, except for a definite preference by boys for, and a corresponding

better performance in, physics topics was found. Results also indicated that girls found chemistry topics more relevant, and demonstrated better performances in chemistry. This seems to echo Lewin's (1993) observation that sex differences in performances are greatest in physics and least in chemistry. A similar result is mentioned in Rennie (2003), on results of 15-year olds in Australia where data collected over three years showed differences that were either trivial, or that favoured girls. Rennie also stated that over the years the well-accepted sex differences in a range of science and mathematics related variables have been found to decrease as boys and girls have had more equal opportunities for participation in relevant activities.

Physiological explanations for conspicuous gender differences in science have often been proffered as an explanation (Koballa, 1996). These hold little water when one reads how the recent performances of girls in science in Thailand exceeds or equals that of the boys (Brickhouse, 2003) or of trends in the United Kingdom currently where there is no overall difference between boys' and girls' performances (Murphy, 1996), or even in this study where overall performance in physical science has been shown to be equitable. In fact Keeves and Kotte (1996) have shown that change in the relative differences in levels of achievement in science between boys and girls can take place over time (drawing on the findings of the First and Second IEA Science Studies), where results in four countries, namely Australia, England, Finland and Sweden showed narrowing of the gap between performances of boys and girls in science studies. Such changes suggest that the causes of such effects are not biological in origin but are associated with factors that involve both societal influences and educational practices. In these countries significant efforts have been made to improve the performance of girls.

The findings in this research project seem to be in contradiction with the literature reviews on gender issues in Africa (Reddy, 1998; Jegede, 1998) though in agreement with current trends reported from some countries like Sweden and Australia (Keeves

and Kotte, 1996). Under-representation of girls and poor performances by girls in science seems to be the trend in most African countries. However, in the sample for this investigation there was equity in the performances of boys and girls. It would appear that the perception of African women as being suppressed, with poor self-image, and under-achievers (Jegede, 1998) does not pertain to this sample of learners, all of whom were black African learners. My explanation for this would be (i) South Africa is a developing country, with a reasonable infrastructure, trying to keep up globally, and the population at large has access to basic amenities, (ii) many 'black' learners hail from single parent homes, where the mother is the sole breadwinner, and she might be the influence behind her child's performance at school, trying to educate them toward a better life, (iii) the population is exposed to 'western' culture, which promotes ideas of equity, (iv) learners doing science in grade eleven were chosen on the basis of good results in grade nine, (v) learners experienced no (gender) bias during lesson time. This was clarified during the focus group discussions. Some learners mentioned that they thought that there was bias, but that this was towards the brighter learners irrespective of gender.

There is, however, still the issue of more boys than girls choosing to do science on higher grade. The number of girls doing science on higher grade in the sample group was only four, compared to the ten boys doing science on higher grade. While this suggests that boys do better in more difficult subjects, analysis of the performances in graphs (only answered by higher grade learners in the examination) showed girls outperforming the boys.

Hughes (2000, 434) states that that "science is a hostile environment for many females learners, whereas male learners dominate the classroom". As a personal observation, though the performances in the examinations were very similar, my experience with the learners in the classroom has consistently been that boys willingly volunteer answers, and question the answers. Girls are the silent ones (except a few), rarely venturing an opinion, and answering questions only when

asked. This may be due to peer pressure, or to gender or to some cultural mannerisms that keep girls quiet.

Although the overall performance in the science examination by boys and girls indicates little gender difference, there is a significant difference in performances in relation to physics and chemistry. This finding supports the differences that have been well documented in recent years for example that by Solomon (1994). By way of explanation, Murphy (1996) maintains that boys' and girls' experiences of scientific equipment and apparatus out of school differs, with boys having a wider range of experiences than girls. Learners' different experiences affects the skills and knowledge that they develop. During group discussions this explanation was also offered by the girls as to why they thought boys performed better. In my experience, boys appear to handle apparatus with more ease than girls, for example when connecting transformers, and trolley tracks and electrical circuits etc. This confidence in handling equipment may explain their preference for physics. Girls tend to be onlookers when these activities go on. Murphy (*Ibid*.) also believes that parents and teachers are responsible for the fact that boys and girls experience school differently, as parents expect different behaviours from boys and girls. Teachers' expectations and judgments of girls' and boys' achievements and needs also have been found to vary in stereotypical ways.

Johnston and Dunne (1996) see some teaching strategies involving trying to change the performance of girls in science by attempting to change some of their learning characteristics to match more closely that of the boys. For example one strategy could be to alter the curriculum to make it more gender-inclusive. Johnston and Dunne also suggest other changes in the early socialization patterns, learning environments or the school organization that could have an impact. Murphy (1996) believes that the relative inexperience of girls can be overcome in an activity-oriented style of science teaching. He mentions that the science curriculum of Thailand,

which appears to support girls' learning, is described as activity-based, learner-centered and focuses on novel aspects of inquiry and discovery.

Current trends, as shown in the international literature (eg. Brickhouse, 2003) show girls performing as well if not better than boys. This appears to have occurred due to concerned parties being aware of the differences and attempting to improve the biased situation. There are still issues that need attention, such as the fact that boys find physics more relevant, and perform better in physics, compared to girls. In fact Cousins (2007) discovered in a study on male and female participation in secondary school chemistry, that comparable numbers of males and females enroll for the chemistry courses. However, the intrinsic motivation was gendered. It emerged from the study that males were motivated to select chemistry because they have a genuine interest or affinity with the subject content, whereas females' primary motivation was more long term or calculated. In other words there is something about chemistry that "awakens a passion within males" (*Ibid*., 728). I think the same applies to physics. If that which attracts males to chemistry/physics can be discovered and then implemented, then perhaps science can become a truly gender-inclusive subject. Until then, implementation of extrinsic factors, like teachers taking cognizance of the differing performances of boys and girls, or the home environment encouraging girls in the physics field, could help narrow the gap in performance between the genders.

5.3 LIMITATIONS OF THE METHODOLOGY

There are some factors that might have impacted on this study that need to be taken into account:

(i). It is questionable whether learners fully comprehended the meaning of the word 'relevance'. This was discovered after administration of the pilot questionnaire, and steps were subsequently taken to try to address this, in that the meaning was explained before they began completing the final questionnaire, as well as being

supplied on the questionnaire itself. However it would seem that some might have confused relevance with scoring well in tests and examinations.

(ii). Some learners might not have answered honestly, merely answering for the sake of answering, resulting in skewed data.

(iii.) The results in the examination were particularly bad, this being attributed mainly to the fact that the examination was an external one. These marks did not compare well with marks the learners obtained during the year. It is not known if the examination reflected fairly on their academic ability, and this might have impacted on the accuracy of the comparison of interests versus performance.

(iv.) English is a second language for most of these learners – filling in the open-ended questions for many of them proved difficult. Many opted not to answer these questions, and many answers indicated little understanding of the question.

(v.) Perhaps options A and B on the questionnaire should have been combined into one option from the beginning. It was originally thought that two separate options would allow for richer information, however, subsequently it appeared that analysis of data might have proven a simpler task with one option instead of two. Both options involved relevance – be it to career or to day-to-day experiences, and relevance was my prime concern.

(vi.) The questionnaire should have been implemented *after* the learners had completed the examination. In this way data might have been more reliable in that all sections had been completed and tested. As it is, learners' data showed more correlation for topics that had been completed, and already tested in the June examination. The section on inorganic chemistry showed the greatest amount of non –correlation. This section, although it had been taught, had not yet been tested. However, this emphasizes the point that learners were not really indicating what they thought was relevant, but rather they were indicating content in which they had performed well.

(vii.) Regrettably, this research project involved the 'old' grade eleven curriculum. There is a whole new curriculum now in place, with a lot more content that is relevant

to the new technological age. Perhaps in that sense this research project may now seem a bit outdated.

(viii.) The very poor results did not provide a big enough range of marks for the statistical analysis – a bit like trying to show that tall men are blond, and then using only short men in the sample.

(x.) A low correlation coefficient was obtained during this investigation – there could be a number of causes for this: (i.) The relationship between relevance and performance was investigated, for which a low correlation coefficient was obtained. These two variables are related through other common variables, such as time spent on studies, and this can interfere with the correlation coefficient, (ii.) There was a restriction in the range of the variables. This means that the performance in the examination was poor, and all the marks were quite low, hence a comparison was drawn between low marks and relevance. A more accurate comparison would have been achieved had there been a variety of marks, high and low to compare with. An analogy would be like that of determining the relationship between height and intelligence, and then using only short people in the sample as suggested above, (iii.) The amount of confidence placed in correlation coefficients is determined by the number of cases represented in the table. If the number of cases is small, and if the coefficient is relatively low, not much confidence can be placed in the exact determination of the relationship. The fact of the absence of relation may be fairly safely judged from a small number of cases, but the exact degree of relation should not be inferred unless several hundred or more cases are used (Thurstone, 1925).

5.4 SUMMARY OF CHAPTER

Despite much hype about relevance and gender in the literature, this research project has indicated that relevance in the case of the sample used, does not affect performance, and that gender too does not impact in a major way on performance in science education. There is however a noticeable difference in the physics/chemistry

preference, which is in accordance with previous studies. Boys prefer physics, girls prefer chemistry, but overall there is no difference in performance.

Perhaps this physics/chemistry difference too will change in time, as has the overall improved science performances of girls, if one notes the trends in some countries. With regard to relevance and its effect on performance, perhaps there is a need to emphasise other factors that affect performance, like motivation and time spent on studies, since relevance does not seem to affect the academic performance in science in any major way. It would appear that perhaps other factors play a bigger role in the outcome of science performance. These probably require further investigation.

CHAPTER SIX – REFLECTIONS-CONCLUSION-RECOMMENDATIONS

6.1 INTRODUCTION

In Duggan and Gott (2002) it is mentioned that the school science curriculum is failing to construct a coherent picture of the subject, its methods and its practices, leaving pupils with fragmented pieces of knowledge. They highlight the fact that the science curriculum is overloaded, difficult and that it lacks relevance to everyday life. These are also concerns that are experienced in South Africa. International mathematical and scientific literacy studies reflect poor achievement of South African learners, indicating problems in teaching and learning in these fields. Alleviating these problems requires an investigation into where the problem arises. Is it poor teaching, irrelevant content, or poor studying techniques that are the root causes of the dilemmas that currently face science education? Many researchers believe that a relevant science education would increase enjoyment, increase levels of motivation for learning, increase value development, and increase actual learning itself (Solomon, 1994). This research project focused on investigating (i) what content learners found irrelevant, and (ii) whether the issue of poor results and disinterest are related to an irrelevant education. A third focus of investigation was that based on another contentious issue in science education, that of gender. Internationally, and in Africa, it has been maintained that girls under-perform in mathematics and science. Various studies have been done to determine the causes for this gender imbalance. This study also attempted to determine if there was a gender imbalance in the performances of a sample of science learners.

6.2 MOST RELEVANT CONTENT

The analysis of preferences and performances of this sample group indicated that the learners thought the section on Vectors to be irrelevant and Equations of Motion to be quite relevant. Information like this can help inform in planning a more workable and successful curriculum. More research into this area is necessary, using learners from different backgrounds, looking into common areas of enjoyment and relevance, and similarly investigating content that is irrelevant and demotivating, so that appropriate steps can be taken to address findings such as these.

6.3 PERFORMANCE AND RELEVANCE

Deficiencies in the traditional school curriculum such as over-emphasis on content, its lack of relevance to pupils' interests, the way that scientific knowledge is presented as technical know-how and the lack of attention to contemporary scientific issues, have been a cornerstone for arguments in support of a more relevant science. A major failure of the current curriculum concerns the declining student enrolment in science courses. Many proponents of relevant, learner-centered science education such as Aikenhead, Duggan and Gott and Sjoberg believe that the answer to the disenchantment with science lies in making science content more relevant to the everyday lives of the learners. To do this requires finding out what sort of science is really needed; which would allow reforms to proceed in a more logical way, lead to a content that articulates with the requirements of today's society and would prepare young people for the opportunities, responsibilities and experiences of adult life. This research project took its cue from this belief, i.e. trying to determine what content learners found relevant. This was investigated, and then compared to actual performance, to see if there was a corresponding improvement in performance. The results seem to indicate that overall there is no correlation between learners' ideas of relevance and their actual performance. Statistical analysis showed no relationship between relevance and performance. This is quite contrary to popular belief, since much literature attests to relevance improving performance (Sjoberg, 2002; Driver,

1994; Fensham, 2003). However some previous studies also indicated no real difference in outcome between traditional teaching approaches and context-based teaching approaches (Bennett, 1999). A recent study discovered that the nations with the best mathematics scores have the least happy, least confident mathematics learners (Tom Loveless, http://www.usatoday, 2006). In fact the study author noted that there was a greater need to focus on subject content, and "be a little less obsessed with enjoying every minute of it" (*Ibid*.). While relevant science education has its merits, and it would make for more interesting content which could be more applicable to day-to-day life, is relevant content the answer to the problems that the science field is encountering today? Learners experiencing difficulties with science has been an age-old problem. The reason why the current discontent with science is felt so keenly might be the explosion of the scientific/technological age, which requires more and more scientifically minded people. Inasmuch as learners and many theorists believe that learners should be taught about "things that matter" like how computers and telephones work, what is often not realized is that how these mechanisms work boils down to basic science content, which therefore should be seen as relevant science. Yet it is this very same content that poses a problem for learners.

There is no easy solution to improving the image of science. It is a difficult subject, requiring much input from the learners if they wish to do well. What is required is extra time spent on the subject, motivation and a desire to succeed, home environments which encourage and support efforts in this field, and qualified teachers who themselves are motivated to teach. Wherever content can be made relevant, it should, though not at the expense of pure science content.

During the focus group discussion learners were questioned about their reasons for choosing to do science. Reasons for their choices ranged from "less theory, more calculation", "fun and interesting", "science is for clever people", "career", to "science is an elite subject." When asked about why they performed poorly, they

mentioned “did not study”, “difficult calculations”, “home pressures”. Their reasons did not include an irrelevant science education. Poor performance is often related to amount of time and importance given to the subject. During class discussions learners make an issue of learning content that they think they do not need, for example many a teacher might have heard their learners say “why do we need to learn this – how will ‘p = mv’ help me in later life?” This dilemma for learners, of seemingly irrelevant content, is felt in every subject, not only science. For example, history learners have issues with learning irrelevant details as much as in geography or any other learning area. Hence it seems that the issue of relevance needs to be further investigated, as well as a series of other factors that might well affect learners’ performance in science.

6.4 SCIENCE EDUCATION AND GENDER

Gender issues in science education are common knowledge. The under-performance of girls in science and minimal representation of females in science related careers have been lamented in many countries. In Africa social factors emphasise the plight of the girls. However, recently there has been some turnaround in a few (see below) countries where concerted effort has been made to improve the gender imbalance. In some countries like Thailand and even the United Kingdom, girls are performing as well as boys, if not even better (Brickhouse, 2003). This may confirm the fact that performance by boys and girls is not biologically determined (as was previously believed), but that performance is socially constructed and negotiated, and can change over time and may be different from one culture to another (Sjoberg, 1996). The current trend of girls performing if not better, then as well as boys in science in some industrialised countries as compared to before, attests to Sjoberg’s beliefs. The sample studied in this research project also bears testimony to Sjoberg’s ideas. There was little difference between the performance of boys and girls in the science examination. This is the finding of one little sample in South Africa. It would be interesting to note the trend in other parts of the country, to identify the current

gender status of science education in South Africa. While there are some trends that have not changed, like the fact that boys do better in physics, and that girls prefer chemistry, evidence shows that where biases are removed (Keeves and Kotte, 1996) this too can change. It cannot be denied that boys as a general rule grow up tinkering with toys, breaking and constructing things, while girls enjoy dressing up their dolls. However, if potential barriers to performance for girls are removed, for example if girls are encouraged from a young age to familiarize themselves with the type of devices and toys that boys are exposed to, if teachers are gender neutral, if girls are included in all activities, and if an equitable education is offered to all parties, then possibly the noticeable trends in science education regarding gender differences might disappear, resulting in a greater representation of females in scientific fields.

6.5 HOW FEASIBLE IS A RELEVANT SCIENCE EDUCATION?

This investigation has found no relationship between relevance and performance. The literature identifies many reasons for implementing a relevant science curriculum, however there seems to be very little real evidence that a relevant science education does in fact make a difference. Apart from the fact that in this study the issue of relevance is questionable, there are many difficulties that surround implementing a relevant science education. Analysis of the questionnaire data showed the learners were interested in a wide variety of topics. Not everyone shared the same interests. Can there be universal agreement on what topics should be included in the curriculum? Even with consensus on topics, translating relevance into curriculum terms is contentious and problematic (Jenkins, 2006). Many teachers would need far more support and training if new topics are introduced. Curriculum innovation would only be as successful as the meaning that the innovation has for the teacher in his or her classroom context (Beasely in Moeketsi, Rollnick and Huddle, 2004). Inadequate in-service training of teachers is currently a major concern regarding the implementation of OBE and C2005 (Jansen, 2003). With relevant science education the content has to be within the competences of the existing

teaching force and not "some pie in the sky cadre of non existent super educators" (Johnson *et al*, 2004, 17). There is also the possibility that real science and its abstract concepts will be watered down or eliminated (Bradley in Smit, 1999). Ideally the science education provided should help learners develop skills, and not just rote learning. Currently the curriculum has the difficult task of matching the domestic examination requirements and yet also recognising shifts in emphasis in the international scene. Can relevant science education cope with this? Osborne (2003) points out that the art to developing successful courses in science education is first to ascertain what interests learners and then to design the curricula accordingly. As he correctly points out, that some might feel it a bit risky to put young people's interests first, it is first society's duty to determine what is worth knowing and then to design a curriculum that introduces learners to major ideas and themes that science has to offer. It is likely that learners of this age are not able to judge the future value of any knowledge. Focus group discussions proved this point clearly, in that learners were hard pressed to come up with curricular content that they would like to learn about. They made mention of current technological innovations, though it was clear that there was no real thought given to 'relevant content' prior to this discussion. It must also be remembered that examinations are still content-based, relevant science education needs still include content.

Finally, it should be kept in mind that curricular innovation is not about putting into place the latest curriculum. It means changing the cultures of teachers, classrooms and schools. Innovations adopted on the surface without concomitant change merely results in one set of textbooks being replaced with another, failing to bring about significant change. Without all-round change, familiar ideas have a stronger hold than innovatory ideas, and "new ideas are often mistaken for old ones with new labels" (Mcdermott, 2006). Needless to say, such a change requires great changes within the culture of science teaching, in the curricula and in all the structures involved with their work, and the methods of teaching science. To many the task

may seem insurmountable, requiring resources that are simply not available (Osborne, 2003).

6.6 RECOMMENDATIONS AND POSSIBLE TOPICS FOR FUTURE RESEARCH

This research project has exposed some areas in need of further investigation. The following are thoughts on research that might shed more light on the findings in this investigation.

- Carry out the same research in a school with learners from a higher socio-economic background.
- Investigate other factors that affect performance, such as time spent studying, relationship with teacher, parental involvement.
- Do the same research on the new grade eleven curriculum, which is supposedly more relevant.
- Carry out the same research, getting teachers' perspectives. Do teachers feel a more relevant curriculum is needed?
- Use a single sex school, i.e. a girls' school to see how performances differ from co-ed schools.
- Implement relevant science content, and evaluate the learners' performances after the content has been taught.

Certain questions need to be answered: (i). What do the findings in this research project mean for school science? (ii) What content should now be taught at schools? (iii). How can schools encourage the learning of scientific literacy?
Greater study and more in-depth investigations are required to (i) confirm or refute the results found here and (ii) provide solutions to the questions posed.

6.7 SUMMARY

Despite the popular belief that relevance makes a difference to performance, the results in this study indicate otherwise. Also, contrary to the situation in many other countries, this study indicated that in the sample under investigation, boys and girls performed comparably in terms of their performance in science.

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