Determinants of Grade 9 Learners' Intention to Select Science/Applied Sciences as Curriculum Stream for Grade 10: An Exploratory Study of Selected Secondary Schools in Amathole District

by

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Submitted in accordance with the requirements of the degree of

Master in Education

At the

University of Fort Hare

Supervisor: Dr BA Brown

December 2009

DECLARATION

I declare that Determinants of Grade 9 Learners' Intention to Select Science/Applied Sciences as Curriculum Stream for Grade 10: An Exploratory Study of Selected Secondary Schools in Amathole District is my work, submitted for the degree of Master in Education, and that all the sources I have used or quoted have been indicated and acknowledged by means of complete references.

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ACKNOWLEDGEMENT

I thank God for giving me the strength to persevere even though at times I felt writing a dissertation as this one was an insurmountable task. I owe much gratitude to my dedicated supervisor Dr Byron A. Brown, had it not been for him and his relentless encouragement, this dissertation would not have been possible. When I felt overwhelmed and tired by the work, he would call to find out how far I have gone since the last time we met. Yet his phone calls would spur me on.

I thank the department of education and the principals of the particular schools for allowing me to use their learners and facilities as research sample and sites. I am truly indebted to you.

Last but not least, I thank my wife and my children for being the pillar of strength, and for encouraging me during those lonely nights while I worked in front of the computer, when other people have gone to bed.

ABSTRACT

In schools in the Amathole District and throughout the rest of South Africa efforts are being made to encourage learners to pursue the Science and Applied Science curriculum stream in Grades 10 to 12. The aim of this study was both to determine and to explore those factors which, according to grade 9 learners, would either attract them to or deter them from following the Science and Applied Science curriculum stream from Grade 10 onwards. The study also sought to ascertain the views of teachers regarding the issues raised by the learners. A sample comprising 346 learners and 3 teachers were involved in the study.

Using both quantitative and qualitative methods within the context of a post-positivist paradigm and utilising questionnaires and interviews, the study found that, consistent with existing research, there are both intrinsic and extrinsic related factors which play a role in the intention of learners to consider pursuing the Science and Applied Science curriculum stream. The intrinsic factors include learners' enjoyment of practical work and love for the Science and Applied Science. Extrinsic factors include perception that jobs in the field of Science and Applied Science compensate well. However, it was the intrinsic factors that pushed the learners to have the intention to follow the Science and Applied Science curriculum stream. Sociological, economic and personal dynamics seem to account for these patterns in the results. By contrast, two key sets of factors deterred the learners from the Science and Applied Science curriculum stream. One relates to factors in their internal loci of control, and the other to factors in learners' external loci of control. The internal locus of control factors had a greater influence, which suggests, according to attribution theorists, that the learners

were inclined to look within themselves for the reasons that deterred them from the Science and Applied Science curriculum stream.

In addition, a cluster analysis was conducted to ascertain whether the demographic profiles of the learners played a role in respect of their intention to pursue the Science and Applied Science curriculum stream. This cluster analysis revealed that, in terms of gender, males were more inclined than females to follow the Science and Applied Science stream. However, it was also significant that peer influence played an important role in attracting males to the Science and Applied Science curriculum stream, whereas it was career interest factors that attracted the females. In terms of ethnic groups, Indians and blacks were more inclined than coloureds and whites to follow the Science and Applied Science stream with whites being the least attracted to this stream. Career choice dynamics provide some explanations for these outcomes.

The key contribution of this study lies in the fact that the study has shown that practical work as a teaching strategy may result in greater learner participation in the Science and Applied Science curriculum stream. The study recommends that, in order to promote greater participation in the Science and Applied Science curriculum stream in schools, strategies related to teaching in terms of which both genders are taken into consideration should be implemented. Other recommendations were also made. Nevertheless, it must be borne in mind that the study is a case study and that it is, therefore, not possible to generalise the findings.

KEY WORDS

Curriculum

Sciences

Applied Sciences

Motivation

Intrinsic factors

Extrinsic factors

Internal locus-of-control

External locus-of-control

Amathole District

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CHAPTER 1

OVERVIEW OF AND RATIONALE FOR THE STUDY

1.1 BACKGROUND TO THE STUDY

Grade 9 is one of 12 grade levels that make up the General and Further Education and Training bands in the education system in South Africa (DoE, 2005:3). It is at Grade 9 that the General Education and Training (GET) band ends, while the Further Education and Training (FET) band commences in Grade 10. Accordingly, it may be said that, Grade 9 is a transition grade between the GET and the FET bands (DoE, 2005:3) although, unlike in the GET band where a general education curriculum is pursued (DoE, 2005:52), learners in the FET band are required to specialise in selected subject streams.

The subject streams which learners may pursue at the FET level include: (a) services; (b) languages; (c) human and social sciences; (d) arts and culture; (e) business, commerce and management studies; (f) agricultural science; (g) physical, mathematical, and computer and life sciences; and (h) engineering and technology (DoE, 2005:52). The Grade 9 'Guide to Higher Education' document classifies the first four of these subject streams as the Humanities and Social Sciences, while the last four are regarded as the Sciences and Applied Sciences (DoE, 2005:68). Each stream consists of different sets of subjects.

Since 2006, after completing Grade 9, learners have been required to pursue a maximum of seven subjects in Grades 10 to 12 (DoE, 2005:51). Four of these seven subjects are compulsory, and these compulsory subjects include two languages, life orientation, and mathematics/mathematical literacy (Bernstein, 2007:1). With the exception of mathematics/mathematical literacy, these compulsory subjects are within the Humanities/Social Science streams (DoE, 2005:51). Learners are, therefore, at liberty to select their remaining three subjects from the list of available subjects in the Sciences/Applied Sciences and/or the Humanities/Social Sciences based streams which are offered at their respective schools (Blaine, 2004:1). This arrangement is in contrast with what was practised prior to 2006 at which time learners decided on their subject streams at Grade 10 level, instead of Grade 9 level, and, in addition, they were permitted to take six, rather than seven, subjects (DoE, 2005:3).

Over the years, learners have displayed a tendency that, when selecting the additional subjects to complete the set of seven subjects for their stream, they often opt for Humanities/Social Sciences-related subjects rather than subjects that are Sciences or Applied Sciences based (CDE, 2007; Crouch & Perry, 2003). This phenomenon is illustrated in the Amathole District in the Eastern Cape where both the annual enrolment rate of Grade 10 learners in the Sciences and Applied Sciences has tended to be low (ECDoE, 2006), and the performance statistics of learners, and schools in general, in both Mathematics and the sciences in the matriculation (Grade 12) examinations remain generally unsatisfactory when compared to other districts and provinces (ECDoE, 2006).

It is quite obvious that the Sciences and Applied Sciences are not favoured. For instance, in 2005, the Education Management Information System (EMIS) reported that, by province, the Eastern Cape had the lowest number of learners (22.2%;

n = 152 000) in Grade 11 who were pursuing subjects in the Sciences/Applied Sciences in that year (EMIS, 2005). Although this data does not reflect the situation at a district level, personal observation during continuous assessment moderation in several secondary schools in the Amathole District in the Eastern Cape revealed incidences in which some schools did not even have Physical Science or Mathematics files for their learners. The absence of such files is an indication of the low numbers of learners – or no learners at all – for whom to compile files.

Provincial statistics between 2006 and 2007 show that, of the estimated 152 000 Grade 9 learners who continued their education to Grade 10 in the Eastern Cape, approximately 139 000 of them (the majority) either did not opt for any or else opted for just one subject(s) in the Sciences/Applied Sciences stream (EMIS, 2007). Even within the Sciences/Applied Sciences stream the pattern in terms of the proportion of learners opting for subjects within the stream is not the same (Huddle, Coville & Michael, 1997; *Mail & Guardian*, 2000). For example, 23 only in every 100 full-time Grade 12 candidates wrote Physical Science in 1996, compared with the 80 in every 100 who wrote Biology in the same year (*Sunday Times*, 1997:7).

At a national level the general situation is somewhat mixed. There is evidence which shows that access to schools in which the Sciences/Applied Sciences and Mathematics are offered beyond Grade 9 is extremely unequal, despite significant efforts on the part of government in terms of financial investment in the education sector (Bernstein, 2007:1). Access is largely structured along racial, class, gender and geographic lines (Bernstein, 2007:1). In certain senior grades there is both a better infrastructure as well as better Science/Applied Science facilities in schools in those provinces which are dominated by certain racial and ethnic groups than in similar schools in other provinces (CDE, 2007). Whether differential conditions at school level influence learners within the same school and/or geographic location within a specific province either to choose or not to choose the Sciences/Applied Sciences subject stream for Grade 10 is not immediately clear from the above data.

Furthermore, in a report on the state of the teaching of mathematics and science in South African schools Bernstein (2007:1) has provided evidence to suggest that a number of Grade 10 to 12 learners in schools in different provinces "…have chosen *not* to do Sciences/Applied Sciences subjects such as mathematics and physical science at all, even when they had the opportunity to do so up to the higher grade level". The same report noted that many other learners who did have the ability found themselves, for personal or, perhaps for other reasons, unable to pursue the sciences and mathematics (Bernstein, 2007:1). This situation was also confirmed in the 2004 CDE study (CDE, 2004:57-56). While these reports do reveal the tendency among learners to opt – or not to opt – for the science and applied science subject stream, these reports have not provided an in-depth understanding of the reasons for these decisions.

At the same time, school dropout studies (Brown, 2009; Porteus, Clacherty, Mdiya, Pelo, Matsai, Qwabe & Donald, 2000) indicate that many of the learners in Grades 10 to 12, including those who opted for the Sciences/Applied Sciences, do not continue with their education to the end of Grade 12. This challenge is highlighted by Kraak's (2004) study which suggests that, of the estimated 826 000 learners who register in schools each year, about 551 000 learners drop out of school between Grades 1 and 11 every year.

Both the decision either to opt, or not to opt, for the Sciences/Applied Sciences and the phenomenon of dropping out of school before completing these subject-streams, have a bearing on skills development and the availability of critical skills for the labour market (Kraak & Press, 2008:vi). Schulze and Nukeri (2002:154) argue that, owing to rapid advances in science and technology, every country, including South Africa, needs to consider the question of how to prepare its youth to live in a scientific, mathematical, and technological world. This rapid advance in science and technology underscores the importance of discipline and the value of encouraging learners to pursue science and technology-related fields.

In view of the importance of the Sciences/Applied Sciences for skills-based careers and the labour market (Bernstein, 2008; CDE, 2007; Kraak & Press, 2008), it is contended that it is essential to gain an understanding of the underlying attractors and deterrents behind learners' decisions or intentions to pursue the Sciences/Applied Sciences. Framing this understanding within context would provide a sound basis for policy decisions.

Previous studies that have examined learner subject/curriculum streams in schools in South Africa have focused largely on either learner performance, or on the pass rates in national examinations subjects such as mathematics and the sciences (Bernstein, 2008; CDE, 2007; Crouch & Perry, 2003), and also on the proportion of learners who drop out of school and who drop out of different subject-streams (Dube, 2007). The research has also concentrated on the demographic characteristics of those involved (Dube, 2007; EMIS, 2006, 2007) and on the intentions to promote both the teaching and learning of Mathematics and Science (Schulze & Nukeri, 2002). There are also studies that have examined the effects of different initiatives to improve Sciences/Applied Sciences performance (DoE, 2007; Mettas, Karmiotis & Christoforou, 2006; Schulze & Nukeri, 2002; Taylor, 2006), and the aspirations of grade 12 learners to enter Higher Education in order to pursue specific careers such as teaching (CEPD, 2005; Morrow, 2007). However, these studies have involved learners who had already opted for the relevant subject streams.

Personal factors such as perceived competence, self-efficacy and motivation (Bandura, Barbaranelli, Caprara, & Pastorelli, 2001; Schunk, 2004), as well as teacher factors such as role models in science and science-related fields, teaching methods (Rop, 1998; Swartz, 1991; Solomon, 1997; Mechling & Oliver, 1995), and home environment (Schulze & Nukeri, 2002:154), have all been advanced in previous studies as explanations for the kinds of decisions taken by learners. Nevertheless, while these explanations do prevail, it would appear that they are limited by two factors: (a) they fail, as Bernstein (2007:1) found in different contexts within South Africa, to take into account instances where learners, despite having the necessary ability and family support, still choose not to pursue the Sciences/Applied Sciences at school level and (b) many of these studies were conducted retrospectively; that is, after the learners had already decided on their subject streams. After learners have already selected their streams it is both difficult and, perhaps, futile to put austerity measures in place to encourage those learners who would, otherwise, have not chosen the Sciences and Applied Sciences curriculum stream to do so.

1.2 FORMULATION OF THE PROBLEM

The evidence discussed above illustrates that the Sciences/Applied Sciences are not a popular stream for learners when the learners select their subjects for Grade 10 (CDE, 2007; Crouch & Perry, 2003). Secondary schools within the Amathole District also experience this same problem (ECDoE, 2006) and many schools in the district have been making an effort to encourage learners to pursue the Sciences and Applied Sciences curriculum stream. Nevertheless, there are some cases where schools find themselves with the Humanities stream becoming oversubscribed, and the Sciences/Applied Sciences undersubscribed.

In terms of current practice in secondary schools within the Amathole District teachers and other school officials are not aware of (or are not in a position to specify) the number of learners who either intend, or do not intend, to pursue the Science and Applied Science curriculum stream, or the reasons behind their decisions. Accordingly, the teachers of Grade 9 learners are not in a position to formulate any meaningful or relevant strategy to convince their learners to pursue the Science/Applied Science stream at the end of their Grade 9 year. Furthermore, there is also little or no evidence, on the gender and racial dynamics prevalent among those learners who intend either to select, or not to select, the Science/Applied Science stream. However, such information could assist school officials to encourage, where possible, more learners to take up the Science/Applied Science stream.

In the literature those particular factors that either attract and/or deter learners from the Sciences/Applied Sciences remain contested (Bernstein, 2007). Bernstein (2007) also argues that there are some learners who often choose not to do the

Science/Applied Science subjects for personal reasons personal (CDE, 2004). There is no clear explanation, for instance, of the reason why certain learners would decide not to pursue the Science and Applied Science curriculum stream in spite of having both the necessary ability and family support (Bernstein, 2007; CDE, 2004).

Within the context of the Amathole District those factors that either attract or deter learners from pursuing subjects within the Science and Applied Science curriculum stream and the ethnic and gender dynamics behind those decisions or intentions remain unspecified. Accordingly, the study poses the following main research question.

1.3 RESEARCH QUESTION

What factors influence the intentions of Grade 9 learners either to select, or to avoid, the Science and Applied Science curriculum stream in Grade 10?

1.3.1 Sub-research questions

The following sub-questions emanate from the main research question:

(a) What are the demographic and school characteristics in respect of those grade 9 learners who intend to opt for the Science and Applied Science curriculum stream in Grade 10?

(b) What demographic and/or school factors in respect of of the Grade 9 learners are significantly associated with their intention to opt for the Science and Applied Science curriculum stream in Grade 10?

(c) What are the attractors and/or deterrents for learners in terms of opting (or not opting) for Science and Applied Science as a curriculum stream?

(d) Do male and female learners differ significantly in these attractors/deterrents in terms of opting (or not opting) for the Science and Applied Science curriculum stream?

(e) What are the views of Grade 9 teachers regarding the issues raised by learners in (c) above, and their implications for promoting the Science and Applied Science stream as a viable curriculum stream?

1.4 PURPOSE OF THE STUDY

The purpose of this study is twofold: Firstly, the study aims both to determine and to explore those factors that Grade 9 learners believe either attract them to or deter them from opting for the Sciences and Applied Science curriculum stream for Grade 10. This involves exploring the demographics and school factors related to these attractors and deterrents. Secondly, the study aims to determine both the reactions of teachers to the factors raised by the learners and also steps that might be taken to promote the Sciences and Applied Sciences as a viable stream in Grades 10 to 12.

1.5 SIGNIFICANCE OF THE STUDY

This study may have both theoretical and policy significance. As suggested earlier (cf. introduction), researchers have tended to focus on the reasons why learners select their specific subjects. These studies have also been mainly conducted retrospectively among post-Grade 9 or 10 learners who, essentially had, by that time, already made their decisions and selected their subject streams. None of these studies focused on Grade 9 learners before they had made their stream decisions. By focusing on learners before they make their subject stream decision this research may begin to contribute to filling this knowledge gap in the existing literature. Secondly, there is a growing number of policy initiatives, such as the Dinaledi science programme (CDE, 2007), to promote the selection of Sciences/Applied Sciences in secondary schools. An understanding of the attractors and deterrents which play a role in the intentions of learners either to select, or not to select, the Sciences/Applied Sciences as a stream may inform strategies at the school level which aim to promote the Sciences/Applied Sciences. The study may also challenge school officials and district education directorates to ensure that their curricula policies address these challenges.

South Africa is in dire need of technical, technological, medical and engineering expertise and, if nothing is done to address this deficiency, the situation may well spiral out of control. The solution should be found within the high schools, to be precise, at the Grade 9 level at which learners have to decide on their Grade 10 subjects. A study of this nature is critical for the provincial schools, districts and national education system because it may provide an understanding of the reason why so few learners are interested in studying the sciences/applied sciences in schools. This may help in the development of strategies to promote the choice of the sciences/applied sciences within schools in order to meet the demand for science-based skills in the country. As a country South Africa must, through its schools, prepare its youth to become effective citizens within a scientific, mathematical, and technological world (Winther & Volk, 1994:50).

1.6 RATIONALE BEHIND THE STUDY

The researcher developed an interest in this topic when he was confronted by the behaviour of both his mathematics and science learners when he was teaching in a high school in the years between 2000 and 2007. At the time, many of the learners, midway their Grade 10 year had started regretting the fact that they had opted for the sciences. Each year, in this period between 2000 and 2007, the researcher observed, much of it negative, the way in which the learners both reacted to the Science and Applied Science stream and chose, their subject-streams.

The researcher also noticed the negative reaction when he was studying a science elective course for his Bachelor of Education Honours degree. The lecturer had asked the B Ed Honours students why they had chosen physical science as a subject at high school, instead of other subjects such as history. The main response was that most of them had been persuaded by their teachers to do physical science. This had led the researcher to wonder whether these individuals could have ended up following streams other than the sciences, and whether this same sort of teacher influence were operating in other schools. The researcher started gaining some indications of the negative attitude of learners towards Science and Applied Science stream whenever he attended science workshops and conferences. During the workshops he found other teachers sharing their experiences of learners "running away" from the Sciences and Applied Sciences curriculum stream. These first hand experiences to which he listened awakened the researcher's interest into investigating those factors which learners take into account when they make their decisions about curriculum streams to be followed in Grade 10. This study is, therefore, pertinent since there is an urgent need to encourage greater participation in Science and Applied Science in schools in South Africa.

1.7 DEFINITION OF KEY CONCEPTS

The following key concepts have been defined in order to reflect on the way in which they have been used in this study.

1.7.1 Science/Applied Science stream

Johnston (2005:11) describes science as a body of knowledge or body of facts associated with particular disciplines such as biology, physics, chemistry, geology, astronomy, psychology, and information and communication technology. Applied sciences refer to the utilisation of scientific knowledge (*Concise Oxford Dictionary*, 1990:52). Accordingly, the Science/Applied Science stream refers to a field of learning which serves as classification label for a defined set of subjects in the New Curriculum in secondary schools within South Africa (Oakes, 1994:485; Sadovnik, Cookson & Semel, 1994:151). This study is guided by the above definition of the Science/Applied Science stream.

1.7.2 Attractor

In this study, the concept of attractor refers to those aspects that learners regard as positive, beneficial, and/or inspirational in terms of their following of Science/Applied Science as a curriculum stream.

1.7.3 Deterrent

In this study the concept of deterrent refers to those aspects that learners regard as negative, challenging, and/or discouraging in terms of their following of Science/Applied Science as a subject stream.

1.7.4 Intention-to-opt

The concept 'opt' means to select, choose, or to decide to do something (*Pocket Oxford Dictionary*, 1984:514). In this study intention-to-opt refers to learners selecting the Science/Applied Science stream, despite other possibilities.

1.7.5 Grade 9 learner

Grade 9 learners are learners in the ninth year of schooling – formerly known as Standard 7 in the secondary school in the senior phase.

1.7.6 Grade 10

Grade 10 refers to the tenth year of schooling – formerly known in South Africa – before the New Curriculum; that is, Curriculum 2005 (DoE, 2000) –as Standard 8. Grade 10 is also the first of the three grades which constitute the Further Education and Training (FET) phase.

1.7.7 Secondary school

According to Pretorius (2007:40-41) secondary school refers to the period of schooling between Grade 8 and Grade 12. In this study this same definition is applied.

1.8 PARADIGMATIC PERSPECTIVES

Maree and Westhuizen (2007) define paradigmatic perspective as the way of viewing the world. When a researcher chooses a perspective he makes certain assumptions and uses certain systems of meaning in favour of others (Maree & Westhuizen, 2007:32). According to Mouton and Marais (in Loock 1999:10) a researcher's assumptions and beliefs reflect his/her way of thinking and, possibly, also the research process. It is for these reasons that the researcher's assumptions and beliefs should be made known to the reader. As Miles and Huberman (1994:4) point out, by being informed of the paradigmatic perspective of the researcher, the reader is able to obtain a more holistic view of the research.

1.8.1 Methodological perspective

The paradigmatic perspective has a significant impact on methodological choices of a researcher (Maree & Westhuizen, 2007:33). Miles and Huberman (1994:4) argue that "To know how a researcher constructs the shape of the social world and aims to give us credible account of it is to know our conversational partner". This includes the assumptions and values that serve as a rationale for the research as well as the criteria the researcher uses for interpreting data and reaching conclusions (Saunders, Lewis & Thornhill, 2003:340). De Vos (2005) stresses that it is essential that the researcher decides on the paradigm within which he/she is working in, and that the researcher details the paradigm selected in the research report in order to maintain communication with the reader.

The researcher deemed a post-positivist paradigm to be a suitable paradigm for this research in view of the fact that a central knowledge interest of this research is to understand the determinants of Grade 9 learners' intention to select, or not select, the Sciences/Applied Sciences as a curriculum stream. The research also aims to understand the reactions of teachers to these determinants. These two foci demand a post-positivist approach (Brown & Schulze, 2007). Within the post-positivist paradigm, aspects of both the quantitative (positivist) and qualitative (interpretivist) approaches are adopted on a phased basis (Saunders et al., 2003:340).

1.8.2 Theoretical perspectives

The theoretical perspective of the researcher is based on the following three theories: (a) Bandura's self-efficacy theory, (b) Attribution theory, and (c) Self-determination theory of motivation.

Bandura's theory of self-efficacy recognises that people will act if they are of the opinion that their actions will produce the desired results (Bandura et al., 2001). Learners at school will complete tasks given by teachers willingly if they have self-efficacy. Pajares (1996:544) argues that learners are prepared to engage in those tasks in terms of which they feel competent while they will avoid those tasks in terms of which they do not feel competent. Self-efficacy causes learners to persevere even if faced with difficult tasks (Schunk in Zimmerman, Bandura & Martinez-Pons, 1992:34). Conversely, learners with low self-efficacy will show resignation and apathy, and an unwillingness to take part in classroom activities (Pintrich & Schunk, 1996).

Learners attribute their success in completing school tasks to four main factors – ability, task difficulty, effort and luck (Weiner, 2009). Ability and effort are within their internal locus of causality while task difficulty and luck fall within their external locus of causality.

Self–determination refers to the process of utilising one's will (Deci in Pintrich & Schunk, 1996:257). Self-determination is realisable if learners have a choice (Shroff & Vogel, 2009). Reeve, Nix and Hamm (2003) argue that self-determined learners act out of choice instead of out of obligation or coercion. Learners who act of their own volition feel both competent and autonomous, and they do not feel pressurised to engage in classroom activities (Shroff & Vogel, 2009).

1.8.3 Assumption about humans

I believe that every person:

- May be taught and is capable of changing the way in which he/she does things;
- May be motivated to act in a way that will yield the desired results;
- Is affected by surroundings and the environment to act in a certain way;

To summarise, learners with self-efficacy learn better than those learners who do not have self-efficacy. Some learners attribute their success or failure to certain attributes. If learners were to be given wider choices and autonomy by their teachers they would become self-determined and their task execution would improve. Learners need encouragement from their teachers.

1.9 DIVISION OF CHAPTERS

Chapter 1: Overview and rationale

Chapter one is an introductory chapter to the research and it sets the tone of the research. This chapter discusses the research that has already been conducted about the topic and also cites the shortfalls of that research. Having reviewed the available literature the reason for conducting this research is presented.

Chapter 2: Literature review

In this chapter the literature that has been studied and interrogated is analysed and the gaps pointed out. Both primary and secondary literature is reviewed.

Chapter 3: Research methodology

This chapter clearly explains the way in which the research will be conducted. The paradigm and the research design used are explained. The sample used in the study is also discussed. All the tools used to collect the data are clearly defined. When data has been collected it has to be analysed and this process will also be clearly explained.

Chapter 4: Presentation of findings

In this chapter, all the data that was collected using the methodology discussed in chapter 3 is analysed and discussed. The quantitative data is analysed in terms of both descriptive and inferential statistics. In terms of the descriptive statistics the mean, mode, range, frequency and dispersion are employed while, in terms of the inferential statistics, ANOVA will be calculated.

Chapter 5: Findings of follow-up qualitative case study and discussion

In this chapter data from a follow-up qualitative case study conducted among teachers of Grade 9 learners will be presented and discussed. The aim of this case study is to obtain the reactions of teachers regarding some of the key issues raised by the learners concerning their reasons for pursuing, or not pursuing, the Science/Applied Science stream.

Chapter 6: Conclusion, recommendations and limitations

In this final chapter the trends will be drawn together and suggestions for further research offered. The limitations encountered in the research will be explicitly stated.

1.10 SUMMARY

This chapter discussed the context of the research and the rationale behind and significance of the study. It outlined the research problem and defined the main concepts. As reflected in the research context it is clear that there is a problem in respect of the Science/Applied Science curriculum stream in the country's education system. The next chapter outlines the literature review carried out around the key concepts and the main research questions posed. The aim of this literature review is to further clarify the main concepts and to assist in developing the research instrument.

CHAPTER 2

LITERATURE REVIEW

PERSPECTIVES ON THE NATURE OF SCIENCE/APPLIED SCIENCE AND FACTORS INFLUENCING CURRICULUM SELECTION

2.1 INTRODUCTION

In the previous chapter both the research problem and background to the study were outlined. The chapter also discussed the rationale behind and the significance of the research and the key concepts used in the study. This chapter reviews the existing literature on Science and Applied Science and discusses what previous research in other contexts had to say about the reasons why learners opt for the Science/Applied Science stream.

Various contentions on learner subject selections have been documented in the literature. It is clear, for instance, that there is a plethora of reasons why learners make certain subject choices. The studies documented report as important to various factors including parental and peer influence, cultural influence and the teaching styles of educators. These themes that emerged from this literature review provided a conceptual framework for this study. The chapter commences with an overview of the structure of Science/Applied Science.

2.2 THE NATURE AND STRUCTURE OF THE SCIENCE AND APPLIED SCIENCE CURRICULUM IN SCHOOLS

2.2.1 Conceptions of the terms Science and Applied Science

According to Hayward (2003) the word “science” refers to knowledge that may be applied over a wide variety of disciplines. Johnston (2005:11) describes science as a body of knowledge or a body of facts associated with a particular discipline such as biology, physics, chemistry, geology, astronomy, psychology, information and communication technology and so on. Turner and DiMarco (1998:20) state that science may be characterised as a particular way of thinking about, and understanding of, the natural world. Tsaparlis (2001) asserts that the term science refers to all sciences, including social sciences. Reiss (2000:17) concurs by stating that there is no one particular science but, rather, there are sciences. This suggests science is an umbrella term and it is not possible to pin the term down to a particular field/discipline.

Turner and DiMarco (1998:191) view science differently as, to them, science is a highly successful human activity – a defining feature of our culture – which ranks alongside the achievements of in the fields of art, music and literatures. Thus, in terms of this view, science is a practice. Turner and DiMarco (1998:21) further argue that there are two aspects to science – the empirical aspect and the theoretical aspect. The empirical aspect includes the collecting of knowledge and the developing of procedures in order to investigate the world. The theoretical aspect comprises mental models that lead to hypotheses that may, in turn, be tested by experiment.

As a discipline there are three parent sciences: physics, chemistry and biology (Tsaparlis, 2001:1) which are all regarded as the pure sciences. Hayward (2003:5), as well, as Farmery (2002), state that the field of sciences/applied sciences may be widened to include biochemistry, astronomy, and genetics etc. The extension of the pure sciences to include these sub-branches of science led to the development of Applied Science which refers to the application of knowledge from one or more natural scientific fields in order to solve practical problems (Wikipedia, 2009).

Applied Science operates within the realm of practice, and is based on systematic and formulated knowledge which is, in turn, based mainly on observation, experiment and induction (Sykes in Farmery, 2002:9). Hayward (2003:5) concurs with this viewpoint when he states that Science and Applied Science have been built over the centuries through observations, investigations and experimentation. These perspectives lead to the conclusion that the nature of science is two-fold in that it consists of both the discipline/field and the practice. Both the discipline/field and the practice are interrelated and, according to Farmery (2002), involve a symbiotic relationship between evidence, interpretation and the establishment of accepted knowledge.

Hodson (2002) argues that traditional school curricula describe science in terms of observation as he maintains that nothing enters the mind except by way of the senses. Hodson (2002) further argues that this interpretation via the senses depends on prior knowledge. Learners from different backgrounds and from different environments may perceive and understand things differently as these different backgrounds and different environments will have an effect in their understanding. This suggests that it is essential that teachers take the learners' prior knowledge into consideration when preparing and presenting their lessons.

Johnston (2005) argues in favour of the notion of taking the learners' prior knowledge into consideration when he states that our understanding of science is shaped by our experiences. Science is, therefore, subjective. Lederman, Lederman and Bell (2004:14) also concur with this thinking when they state that the influence of prior conception on observations means that science is not objective. This implies that observations are biased by our theories, laws and beliefs, while bearing in mind that scientific theories are tentative (Turner & DiMarco, 1998).

Harlen (2006) concurs when she maintains that science is an human endeavour which depends on creativity and imagination, and on the skills of gathering and interpreting evidence. Turner and Di Marco (1998:20) also stress the notion of science as a product of the human drive to be curious about the environment. Harlen (2006:35) further states that scientific ideas originate in the way in which human beings make their sense of their experiences. Farmery (2002:9) agrees when she asserts that we make sense of science through our own thoughts and also through the thoughts which pertain to our cultural environment. Harlen (2006:34) maintains that science should be about understanding or, in other words, about arriving at possible explanations of and relationships between observed events which, in turn, render it possible to make predictions.

Lederman et al (2004:15) state that scientists usually select the simplest explanation for any phenomena and that they draw inferences that are consistent with prior knowledge and understanding. This allows for predictions to be made
and prior knowledge to be used. Lederman et al (2004) further assert that the body of knowledge with which learners should be acquainted includes the laws, theories, concepts and principles of science. They go on to state that the body of science that learners acquire at school should be made up of biology, chemistry and physics.

Biology involves the structure and function of living things, chemistry is about atoms, molecules, and compounds and their interactions while physics involves the forces that govern the physical world (Lederman et al, 2004).

It is clear from the above that both science and applied science may be treated as both a discipline as well as a field of study. It is this perspective that shapes the structure and contents of the sciences and applied sciences in the school curricula.

2.2.2 The disciplines of the sciences and applied sciences

The disciplines in science range from the natural sciences to social sciences (Tsaparlis, 2001). Natural sciences include biology, the earth sciences and the physical sciences (Johnston, 2005). The latter refer to physics and chemistry (Maarschalk & McFarlane, 1988).

Biology includes a set of disciplines that examine phenomena which are related to living organisms (Abruscato, Fossaceca, Hassard & Peck, 1986). The well-known biological fields include botany and zoology. Biology is concerned with the characteristics, classification and behaviours of organisms as well as the way in which the species interact with their environments (Barnhart, 1986). Biology was revolutionised by Darwin's theory of evolution through natural selection which implied that living species are neither permanent nor immutable (Webb & Glover, 2004). Abruscato et al (1986) state that that part of the earth where living things are found is as known the biosphere.

Earth Sciences are also known as the geosciences and it encompasses all those sciences which involve this planet – earth (Abruscato et al, 1986). These geosciences include geology, geophysics, hydrology, meteorology, physical geography, oceanography and soil science (Abruscato et al, 1986). The earth sciences are related to the applied sciences.

Barnhart (1986:495) explains that physics deals with the study of the constituents of the universe, their properties, and the interrelationships of matter and energy. Physics relies heavily on mathematics in order to formulate and to quantify principles (Wikipedia, 2009). The field of physics is broad and it includes quantum mechanics, theoretical physics, applied physics and optics (Barnhart, 1986). Widely known developments in physics include Newton's theory of universal gravitation and classical mechanics and also Einstein's theory of relativity (Lombard, Pearson, Thomas & Lombard, 2006).

Chemistry deals with collections of atoms such as gases, molecules, crystals and metals (Lombard et al, 2006; Abruscato et al, 1986). Barnhart (1986:102) further states that chemistry involves the properties, compositions, structure, and interactions of matter, and the energy changes that accompany these interactions. Abruscato et al (1986) stress that chemistry involves the study of the composition and statistical properties of materials, in particular, the study of transformations and reactions in materials such as gases, crystals, metals, and atoms etc. The prevalence of industrial and mining activities in South Africa means that chemistry is an important science within the country (Gibson, Smith, Chamberlain, Falcon & Gerrans, 1997).

Astronomy refers to the science of celestial objects and it is concerned mainly with the evolution, chemistry, meteorology and motion of celestial objects, as well as the formation and development of the universe (Wikipedia, 2009; Abruscato et al, 1986). Astronomy includes the study of stars, planets, comets, galaxies and the cosmos (Abruscato et al, 1986). Galileo was instrumental in the development of this discipline when he invented the telescope and, thus, made it possible to study the sky at night. Today there are observatories throughout the world which study the stars. South Africa is a country with a well established observatory (South African Observatory) and astronomy is an aspect of science that is being promoted throughout the country (Wikipedia, 2009)

Cross-disciplines or Applied Sciences: There are certain sciences which are used in other sciences. For example, physics is used to explain phenomena in the field of astronomy and this has resulted in a cross-discipline known as astrophysics (HESA, 2005). There is a wide range of this type of cross-discipline sciences, namely, geophysics, physical chemistry, biochemistry, geochemistry and biophysics (Wikipedia, 2009). A whole range of disciplines of applied sciences is documented in Wikipedia Foundation (Wikipedia, 2009) and include, *inter alia,* aspects of optics and forestry sciences which are the result of work which has been done in cross-science disciplines. The above discussion provides an indication of the contents pursued by learners who select the SAS in school.

2.3 SCIENCES AND APPLIED SCIENCES AS FIELDS OF STUDY IN SOUTH AFRICAN SCHOOLS

2.3.1 Historical perspectives

Prior to 1994 the apartheid state managed the curriculum policies. These curriculum policies may be described as racist, Eurocentred, sexist, authoritarian, prescriptive, unchanging, context-blind and discriminatory (Jansen in Ramsuran, 2005:1). The apartheid regime saw fit not to teach an African child mathematics (Wilcox, 2004). As Verwoerd (in Wilcox, 2004:8) states: "What is the use of teaching the Bantu child mathematics when s/he cannot use it in practice…that is quite absurd". This policy has resulted in the current shortage of skilled science/applied science and mathematics teachers.

After 1994 there was rapid transformation and the democratisation of the education system (Le Grange, 2004). In 1997, Curriculum 2005 was introduced and this signified a major reform in South African education (Masehela, 2005:22). Those individuals, who had been marginalised particularly, in the Science/Applied Science stream, were afforded the opportunities to pursue science subjects (Le Grange, 2004). The new curriculum was based on constructivist epistemology in terms of which learners become actively involved in their learning (Masehela, 2005). Physical science and mathematics were central in the new curriculum together with aspects of applied science (CDE, 2004; Masehela, 2005). It should be noted that Wilcox (2004:5) maintains that mathematics and science/applied science are fundamental to human development and to the functioning of society.

2.3.2 Components of the Natural Science curriculum

According to the Department of Education (DoE, 2002) the Natural Science curriculum which is being implemented at Grade 9 level in schools is a combination of various sciences. These sciences are reflected in the following themes that are dealt within the curriculum (DoE, 2002:61): Life and Living which focuses on life processes and healthy living, on understanding balance and change within environments, and on the importance of biodiversity, Energy and Change, which focuses on the way in which energy is transferred in both physical and biological systems, and on the consequences of human needs and wants for energy resources, Planet Earth and Beyond which focuses on the structure of the planet and the way in which the earth changes over time, on understanding why and how the weather changes, and on the earth as a small planet within a vast universe and, lastly, Matter and Materials which focuses on the properties and the uses of materials, and on understanding the structure, changes and reactions of materials in order to promote the changes which are desired.

It may be seen from the above that the Grade 9 Natural Science curriculum includes themes ranging from Physics, Chemistry, Biology, and Agricultural Science to Geography. A more detail discussion of each theme within the curriculum will now follow.

2.3.2.1 Life and Living

According to the Department of Education (DoE, 2002:64) the Life and Living theme is divided into the following three subsections – life processes and healthy living, interactions with the environment and biodiversity, and change and continuity. Under the subsection of life processes and healthy living teachers deal with human growth, reproduction, and conception including sexually transmitted diseases and HIV (DoE, 2002). Teachers also deal with plants as source of food, the process of photosynthesis, and the human circulatory and excretory systems (DoE, 2002). This suggests that both social and human biology are addressed in this subsection.

Key aspects of the Life and Living theme include the ecosystems, food webs and food chains. The way in which these aspects are treated in the curriculum is based on the principle of sustainable development and it would appear that, by linking these aspects to sustainable development, it becomes possible to address the issues of pollution and recycling (DoE, 2002). In the biodiversity, change and continuity aspect of the Life and Living theme in the science curriculum the difference between organisms in terms of natural selection is covered as well as variations in human biological characteristics such as skin, colour and height which are used to categorise people (DoE, 2002:65). It is clear that the Life and Living aspect of the curriculum draws on both the pure and the applied sciences.

2.3.2.2 Energy and Change

The content covered in the Natural Science curriculum for Grade 9 indicates that the energy and change theme is closely linked to physics as a science (DoE, 2002). The energy and change theme in the curriculum is designed to cover the key concepts and principles of energy, namely, kinetic energy, potential energy, work and power (DoE, 2002). The theme, in turn, informs learners of the way in which energy works and, hopefully, highlights for them the importance of conserving energy, particularly in view of the current Eskom electricity crisis. The energy and change theme provides a means of enabling learners to gain broad, factual knowledge without a deep understanding (Hirsch, 2001). However, Hirsch (2001) states that neither the deep understanding pole nor the lots-of-facts pole is an optimal approach to teaching and learning as, for effective teaching and learning, both poles need to be taken into account.

2.3.2.3 Planet Earth and Beyond

According to the DoE (DoE, 2002) the themes covered in the Planet Earth and Beyond aspect of the curriculum are designed to convey the message that the planet earth does not exist on its own and that other planets do also exist. The themes covered in this aspect of the curriculum also enable learners to discover the reason why the different planets stay in orbit. Curriculum 2005 highlights the importance of the planet earth component of the curriculum. Hirsch (2001) argues that, if society wishes to educate its youth to become well-rounded citizens and lifelong learners, then exposure to Planet Earth studies is a critical component of such an education. Sefako (in HESA, 2005) also believes that Planet Earth studies provide a transition into those applied sciences which are related to astrophysics.

2.3.2.4 Matter and Materials

Everything in the world is made up of matter. It is essential that learners come to know this and the applicability of this fact in the world. The DoE (DoE, 2002) states that it is important for learners to understand the way in which matter behaves as this would help them to become better citizens. For instance, they would be able understand the effect of veld fires on the ecosystem.

2.3.3 Components of the Applied Science curriculum

2.3.3.1 Technology

According to the *Pocket Oxford Dictionary* (1984:772) technology is the study or use of mechanical arts and applied science. There are four subjects offered at secondary/high school level under the heading of technology (HESA, 2005). HESA (2005) lists these subjects as civil technology, electrical technology, engineering graphics and design and mechanical technology. Many of the abovementioned disciplines may be found in the South African school curriculum.

James, Naidoo and Benson (2008) are of the opinion that civil technology may be of assistance to a nation especially, in South Africa, in the context of building RDP houses as learners will come out of school with the required skills. James et al (2008) also state that, more than ever before, South Africa needs qualified individuals who would be able to use their entrepreneurial skills in order to compete in the international arena. However, for this to happen, James et al (2008) argue that a generation of young minds – skilled in and passionate about science and technology – is needed so as to put South Africa on the global technological map and, thus, enable the country to compete internationally. This emphasises the significance of the applied sciences.

To summarise, the above provides an idea of both the natural sciences and the applied sciences to which Grade 9 learners are exposed in school. According to the Department of Education (DoE, 2002) the aim of having a wide range of topics in natural science is to provide the learners with a broad understanding of the Sciences and Applied Sciences (SAS) so as to enable them to make wise choices for Grade 10.

Nevertheless, there has been criticism of the breadth of the grade 9 SAS curriculum and it is argued that this breadth within the curriculum allows little opportunity for learners to develop an in-depth knowledge of the areas within the SAS so as to enable them to make meaningful decisions at the end of Grade 9 (Gibson et al, 1997). Tstyles (2009:1) concurs with viewpoint by maintaining:

> Logically children will not have much appreciation or excitement on the topic by only scratching the surface of these many issues of study in one year. He concludes that, amidst the volume of information that is "stuffed the heads" of learners after a year, learners grasp not much, if anything.

However, Hirsch (2001) counters this idea when he states that it would not be possible for learners to acquire a deeper understanding of the SAS without first acquiring a broad factual knowledge. According to Hirsch we should teach a diversity of subjects that will, in turn, lead to broad general knowledge (Hirsch, 2001:23).

In Grade 10 SAS is structured around three learning fields, namely, Agricultural Science, Engineering and Technology, and Physical, Mathematical, Computer and Life Sciences (HESA, 2005). Each learning field consists of a number of subjects.

However, a recent study has shown that, in most rural schools which have modest facilities or resources (classrooms, laboratories and books), the subject options are limited and learners are able to pursue only what teachers are able to offer (Howie, 2003). This is a systemic factor that constrains the SAS curriculum provided in certain schools.

When learners opt for Engineering and Technology they have the choice of four subjects, namely, civil technology, electrical technology, engineering graphics and mechanical technology (DoE, 2002). In terms of the Physical, Mathematical, Computer and Life Sciences a learner has the option of five subjects, namely, physical science, mathematics, mathematical literacy, computer applications technology and information technology (DoE, 2002). Recent studies have shown that, due mainly to a shortage of resources it does happen that learners have the option of physical science, mathematics and mathematical literacy only, (Bernstein, 2007; Masehela, 2005). However, the *Government Gazette* (1998:30) stipulates that a learner's subject choice should be limited only by the need for coherence, adequate depth of learning, and the requirements of further and higher learning and work. Nevertheless, while provision is made for learners to choose a particular stream, limited resources do disrupt this possibility in some schools. Thus, although in theory there is a wide range of choice as far as Science/Applied Science is concerned, the learners in most schools are able to do only what their teachers are capable of offering.

2.3.4 Approaches to Science and Applied Science subject selection

In most secondary schools in South Africa learners are grouped in their respective classes depending on their numbers. The Department of Education (DoE, 1998:30) policy document states that the new FET curriculum offers multiple entry and exit points as well as a diversity of learning programmes and qualifications to meet the varied needs of learners in different fields and at different stages of their lives. It further This policy document further states that a learner's choice will be limited only by the need for coherence, adequate depth of learning, and the requirements of further and higher learning and work (DoE, 1998).

Reiss (2000) is of the view that the approach to subject selection for Grade 10 in South African secondary/high schools constitutes a form of tracking. Sadovnik, Cookson and Semel (2001) explain that tracking refers to the placement of learners in specific curriculum streams based on certain criteria such as interest, inclinations, and abilities and so on. Shiendler (2008) argues that the current streaming practice in most secondary/high schools in South Africa is not as straightforward as it would appear. She contends that this current streaming practice involves a process in terms of which learners are further disaggregated into sub-groups after they have selected a particular stream (Shiendler, 2008). Reiss (2000) refers to these sub-groups as a class group of a particular stream, and contends that class-groups are necessary in view of the sheer weight of numbers of learners who may select a particular stream (Vanfossen, Jones & Spade, 1987).

2.3.5 Relationship between streaming and learner factors

Evidence from countries in the Southern Africa Development Community (SADC) Region and overseas suggests that the current practice of sub-dividing learners who select a particular stream is not unique to South Africa (Reiss, 2000; Sadovnik, et al, 2001). Schools in both Europe and North America engage in tracking (Oaks in Sadovnik et al, 2001:133). Reiss argues that it may happen that the evidence on which learners are initially allocated to a particular stream (lower or upper ability class) is often insufficient at the start of the year. This implies that low ability learners may find themselves in upper ability groups or vice versa. Reiss (2000) concedes that streaming makes good sense because it is a convenient approach to organising learners for the purposes of instruction. Nevertheless, it would appear that the criteria used for the sub-dividing of the groups are controversial.

Sadovnik et al (2001) argue that, although tracking/streaming is supposed to be based on both the inclinations of the learners and their interest in reality, it is, in actual fact, based on other criteria such as the learners' race, gender, or class. In England and Wales classes are divided according to ability, namely, the foundation class (lower ability), merit class (middle ability) and special class (top ability) (Reiss, 2000). In the United States of America, Sadovnik et al (2001) found that class is a major factor dictating streaming but concede that race, ethnicity, age and gender also play a role. In short, learners are sometimes placed in specific streams because of structural inequalities that have little or nothing to do with the individual's merit or abilities. Shiendler (2008) states that, in the South African context, the criteria for placing learners in groups are often stated "upfront" in policy documents but that, in practice, these criteria may be circumvented by factors such as limited resources and facilities.

Furthermore, there is evidence that teachers tend to favour high ability groups at the expense of low ability groups (Oakes, 1985; Goodlad, 1984). Evidence has shown that tracking has a negative effect on learners in low economic classes (Oakes, 1992). Oakes (1992) found that learners from affluent families and affluent backgrounds are always afforded the best streams in preparation for better job opportunities because their parents are in a position to lobby for them to be placed in the upper streams. Placement in different streams is carried out by means of standardised tests, scores, and teacher and counsellor recommendations. However, these measures are all questionable because of the role of subjectivity and this, in turn, may place those learners who are assigned to the lowest ability classes at a disadvantage (Reiss, 2000).

It is unclear whether the abovementioned factors play a role in the mental state of learners when they are considering which stream to pursue. Another aspect in respect of the approach to SAS stream selection in secondary schools in South Africa is the fact that Physics and Chemistry are taught as a subject which is known as Physical Science. This means that, should a learner choose the science stream, he/she will do both Physics and Chemistry up to Grade 12 if his/her choice of Physical Science is combined with mathematics and either biology or accounting, depending on the future trajectory career of the learner in question. On the other hand, in the applied science of technology stream the subjects of civil technology, electrical technology, engineering graphics and design and mechanical technology are taken (HESA, 2005). In the above listed curriculum streams, mathematics or mathematical literacy is compulsory (HESA, 2005). This approach to the combination of the sciences is consistent with practice elsewhere in the world, for example, in the Netherlands (Krüger & Michels, 2008).

2.4 FACTORS THAT PLAY A ROLE IN LEARNER SELECTION OF THE SCIENCE AND APPLIED SCIENCE CURRICULUM

Studies have shown that both contextual and personal factors mediate a learner's decision to pursue a particular subject stream in school (Amos & Boohan, 2002; Sears, 2000 Reiss, 2000**;** Owoyele & Toyolo, 2008; Marsh & O'Mara, 2008, Hoffmann-Barthes, Nair & Malpede, 1998; Schunk & Pajares, 2002; Kiemanesh, 1998). These contextual and personal factors include the following.

2.4.1 Learner factors

2.4.1.1 Influence of curiosity and societal demand

Amos and Boohan (2002:4) argue that learners study Science and Applied Science in order to satisfy their curiosity about the world around them, to engage in direct experience, to understand the way in which science contributes to technological change, to be able to recognise the cultural significance of Science and Applied Science, and to be in a position to question and to discuss science-based issues. Sears (2000:43) concurs when he states that children study science in order to understand the world around them. Both of these arguments reflect fairly optimistic positions on which teachers may build as they engage in SAS teaching.

Reiss (2000) argues that the teaching of science should not only be about providing the learners with skills and information but that it must also be relevant to their daily lives and stimulate their curiosity. Furthermore, Reiss (2000) believes that issues such as pollution, global warming, sexuality and health education are topical/significant enough to draw immediate attention and that these issues may be integrated into the teaching of Science and Applied Science in order to arouse the interest and curiosity of learners in the Science and Applied Science stream.

Amos and Boohan (2002:4) view science as a contributor to the personal and intellectual development of learners, to their decision-making skills as well as to enabling them to work with others. Hayward (2003:5) discovered that a key aspect of the reason why learners choose the Science and Applied Science stream is to enable them to make informed decisions as citizens of the twenty-first century. Studies have shown that the Science and Applied Science stream is also pursued in order to address the need for future scientists (Amos & Boohan, 2002; Hayward, 2003).

2.4.1.2 Peer Influence

Boaler, William and Zevenbergen (2000) make the point that human beings do not exist in a vacuum but rather in a society with social impact. This draws attention to the influence of peers on learners at school. Studies have shown that a learner's self esteem, self-awareness and self-concept play a critical role in peers' decision making (Owoyele & Toyolo, 2008; Marsh & O'Mara, 2008). A learner with a low self-esteem would usually find it difficult to withstand the ridicule of fellow learners should the former not do well in a subject (Ormrod, 2008). Boaler et al (2000) found, for example, that peer pressure plays a significant role in the subjects of mathematics and science.

Peer pressure may shape learner's decision whether or not to choose the Science/Applied Science stream (SAS).

Studies on peer influence have found that, in most cases, learners find themselves required to conform to group rules even if they do not agree with these rules. This situation is exacerbated in the case of the learner with low self-concept (Schunk & Pajares, 2002; Kiemanesh, 1998). However, Boaler et al (2000) argue that learners view belonging to a group as a "sense of self" and, as a result, they derive self-esteem from belonging to a particular group. Boaler et al's (2000) argument is that a peer group may constitute either a positive or a negative social force. Nevertheless, in general, the influence of peers in terms of the subject choice decision is a reality for many individuals, but it remains to be explored whether this shapes the intentions of learners within the rural school context in South Africa.

2.4.1.3 Gender and cultural factors

In most African countries the rate of illiteracy is higher among women than among men. However, the exception is South Africa where there is no substantial difference between the two (Hoffmann-Barthes et al, 1998). In African societies the education of boys is given preference (Hoffmann-Barthes et al, 1998) while it is traditionally viewed as a waste of money and time to educate girls. Despite the fact that gender differences do not appear to play a role at the elementary level in science (Blosser, 1990) evidence does show that, at secondary school level, girls tend to drop the sciences and mathematics (Bernstein, 2007) as their attitude towards science/applied science seems to be more negative than that of the boys (Blosser, 1990). In other words, at high school level the number of girls in the science and applied science classes plummets drastically in almost all African countries (Hoffmann-Barthes et al, 1988).

There is evidence that attributes this situation to cultural stereotypes and socialisation as boys are encouraged at an early age to carry out SAS related activities such as fixing electrical appliances (Blosser, 1990). However, there are other studies that attribute the situation to a fear of the sciences and mathematics and anxiety regarding mathematics and science learning (Ormrod, 2008).

- Mathematics and science anxiety

Ormrod (2008) reports that, as early as primary school, it would appear that most learners do not like arithmetic as they are often expected to recite their times tables from 2 to 10 standing against a wall and, if a learner is not sure of an answer he/she is caned. This creates anxiety in learners and in girls in particular because of the pain and humiliation

Of all the subjects taken at school not one seems to elicit as much anxiety for as many learners as mathematics (Ormrod, 2008:481). In most cases this anxiety is caused by the way in which teachers teach mathematics. This mathematics anxiety has a ripple effect on science and the applied sciences as these subjects are related to mathematics in terms of computation. The knowledge that a learner acquires in mathematics is useful in terms of the sciences but, if a learner is experiencing mathematics anxiety, then this learner will tend to shy away from the sciences as he/she will not have the required tools to navigate his/her way through the sciences (Ormrod, 2008).

A learner with mathematics and science anxiety believes that he/she is incapable of succeeding in these subjects (Ormrod, 2008). Nevertheless, anxiety in these subjects is not always the result of the way in which teachers teach the subjects, but is sometimes caused by the way in which the curriculum is designed. Some curricula introduce mathematical concepts and procedures before the learners are cognitively ready for them (Ormrod, 2008:481). When learners are faced with seemingly unconquerable questions they tend to disengage from the tasks at hand. This implies that the curriculum structure may prevent learners from developing the skills necessary to understand the content and this, in turn, may cause learners to avoid the SAS stream.

Furthermore, when learners fail in a subject they become frustrated and they develop a negative attitude towards the subject. Learners with high anxiety perform poorly and are, thus, extremely unlikely to pursue mathematics and the sciences in higher classes (Ormrod, 2008). This anxiety is found in both boys and girls but it is more prevalent in girls, and it discourages learners from pursuing careers in the sciences (Ormrod, 2008). Certain teachers use norm-referenced assessment and this leads to competition. Competition increases anxiety, particularly in girls. It has been found that competitive activities encourage learning on the part of boys but that it has a negative influence on girls, while the opposite is true in respect of cooperative learning (Fennema, 1990). All these factors may play themselves out in terms of learners' intentions to select a particular subject stream.

- **Fear of the unknown**

Boaler et al (2000) as well as others researchers (CDE, 2004, Blaine, 2004) are of the opinion that even learners who are successful in mathematics give up the subject as soon as they are able to despite the fact that they are aware that this could limit their future careers. Accordingly, it is evident that there are learners who shy away from mathematics or the sciences not because of inability but because of other factors. These factors can include no role models in their societies, low self confidence in mathematics and science.

When learners come home from school with tasks that they have to hand in the following day these tasks may become an insurmountable problem should they need assistance as there are often few people who are adept in the sciences and, thus, able to offer assistance. This tends to dampen their enthusiasm about continuing with the subject as they would be isolated should the subject become too complex. Those learners who do continue with the subject often do badly as is proved by the fact that, in 2002, 20% only of black South Africans passed physical science in the higher grade (Gaigher, Rogan & Braun, 2006). Learners tend to think that science is only for the teacher, given their expert knowledge. They often hold the belief that they will not be able to understand or gain the same level of competency as their teacher. Consequently, they develop a negative attitude towards the subject, thus dropping it as soon as possible (Blaine, 2004).

In Zambia and Zimbabwe it is compulsory for girls to take physical science and mathematics to secondary school level although the girls perform more poorly than the boys in both countries (UNESCO, 1999). In most other countries in Africa there are fewer girls taking physical science and mathematics than boys and this fact has been attributed to the perceived masculinity of these subjects (UNESCO, 1999). At school level it would also appear that girls turn away from the sciences as there is a shortage of female science teachers as role models for girls (Fenemma, 1990).

In South Africa, Education White Paper 2 (1995) encourages women to take physical and applied sciences and mathematics in order to promote the further development of the entire country. Recent evidence shows that the number of girls who are taking, and passing, physical science and mathematics is increasing and this is evidenced by the fact that, despite the fact that there was only a small difference, the percentage of girls who passed mathematics in the higher grade in 2002 was higher than that of the boys (girls 58, 6% and boys 57, 3%) (Masehela, 2005). Some researchers attribute this growth in the number of girls taking mathematics and the sciences to efforts by government to promote SAS throughout the country (cf. section 2.5).

Demographically the number of girls who opt for physics is much lower than the number of boys although girls are better represented in chemistry and biology (Barmby & Defty, 2006). In a study conducted in the United Kingdom by Barmby and Defty (2006) it emerged that the most disliked subject was physics although physics is definitely less popular with girls than with boys. Kleinfeld (1998) associates the interest on the part of boys in the sciences and mathematics to hormonal factors and states that the hormone testosterone plays a vital part in spatial-rotational skills. Kleinfeld (1998) further argues that aging men who were given testosterone showed an improved performance in visual-spatial tests.

However, Haste (2004:1) argues against this stereotype when she says “If we want to get girls more interested in science and technology, we must move away from purveying the ‘space and techie’ stereotype”. In a survey conducted by the BBC in 2004 it was established that both boys and girls are of the opinion that the sciences are important but that there is a marked difference in their interests. Haste (2004) argues that it is not that girls are “turned off” by the sciences but that they are more concerned about ethical issues in the sciences. The preceding discussion shows the influence of gender and cultural factors in the subject choice decisions of learners.

2.4.1.4 *Language*

South Africa is an extremely diverse society and this is reflected in the fact that there are 11 official languages. Zenex (2003) affirms this fact when stating “The DoE language policy acknowledges the multilingual nature of our society and articulates the official policy of additive bilingualism”. Nevertheless, despite the fact that the Eastern Cape is a predominantly Xhosa speaking province, the language of learning and teaching (LOLT) in the province is English – in other words, English is the *lingua franca*. This means that, in the science class, learners have to understand and use formal scientific discourse in English.

However, English is spoken by less than 10 percent of the population only (Howie, 2003). The Zenex Foundation (2003:6) argues that the majority of learners do not have sufficient exposure to English, either at home or at school, to enable them to develop the English literacy skills necessary to cope with learning through the medium of English. All content subjects are taught in English and most learners struggle with this as English is their second language and, thus, not a language which they use it in everyday life. Howie (2003) argues that one of the causes of the high failure rate in Science and Mathematics is the language problem.

The Zenex foundation (2003) concurs that poor English language skills among both teachers and learners have been identified as one of the key factors that impact negatively on Mathematics and Science examination results. The fact that in the Third International Mathematics and Science Study (TIMSS) learners fared badly in those questions which required that they write an explanation illustrates the point that the language is a cause for concern. In this regard it is pertinent that those learners able to speak either English or Afrikaans fared better than those learners who speak African languages (Howie, 2003).

Setati (2008) argues that English is a language of power and that the effect of English is felt not only to exist in the business world but also in the classroom. Zenex (2003:7) agrees that the power of English within the political economy is such that parental opinion is strongly in favour of English medium education as a means of acquiring English and, thus, securing access to economic resources.

According to Setati (2008:104) English may be used either to exclude people from, or to include them in, conversations. This may happen in a science/applied science class situation if a teacher does not explain concepts in such a way that learners are able to understand what is being explained. Nevertheless, Taylor (in Zenex, 2003: 7) proposes another view when stating, “While home-language instruction is preferable, the rudimentary nature of the academic register in most South African languages for physics, chemistry and mathematics still requires the development and agreement on a multitude of technical terms. This development would take massive inputs of resources and time".

One of the recommendations put forward by CDE the (2004) was that the National Department of Education should recruit science and mathematics teachers from neighbouring countries in order to alleviate the shortage of teachers. These teachers would come armed with content knowledge but without any knowledge of the language of those learners whom they would be teaching. Accordingly, English would have to be the medium of instruction. The problem may be exacerbated by the fact that some of these teachers would have different accents to which the learners would have to become accustomed before being able to grasp what they were being taught.

2.4.1.5 Learner self efficacy and motivation

- Self efficacy

People prefer to engage in those activities in which they are certain to succeed and, ultimately, be rewarded. Self-efficacy is defined by Bandura (in Pintrich & Schunk, 1996:161) as people's judgement of their capabilities to organise and execute courses of action required to attain designated types of performances. According to the behaviourist theorists, behaviour that has been reinforced will reoccur. People will act if they think they will be able to achieve the desired effects (Bandura et al, 1996). When people are of the opinion that they are self-efficacious they tend to act willingly. This fact could help learners to achieve better results in SAS if they could come to believe that they were self-efficacious.

According to Bandura (in Pajares, 1996:554) self-efficacy refers to a belief in one's capabilities to organise and to execute the courses of action required to manage prospective situations. This is extremely relevant in the school situation as it would mean that learners would become cooperative and actively involved when performing activities that they both enjoyed and about which they were certain of positive results. Conversely, if the results were negative, learners would become hesitant to act.

Pajares (1996:544) and Bandura et al (2001) concur when they state, "People engage in tasks in which they feel competent and confident and avoid those in which they do not". Learners with high self-efficacy fare better in performing tasks than those learners with low self-efficacy. Accordingly, self-efficacy is predictive of the quality of a learner's execution of a task as self-efficacy contributes to the academic achievement of the learner. Pintrich and Schunk (1996) stress this point when they maintain that self-efficacy does not merely involve being good at school but that it also involves the ability to perform tasks of varying levels of difficulty well.

When learners are faced with difficult tasks they will persevere if their perception is that they will be able to achieve the desired results. Thus, this perception will strengthen the commitment of learners to tackle tasks with conviction. Self-efficacy and outcome are related concepts. Nevertheless, Pintrich and Schunk (1996) stress that it is possible for a learner to have high self-efficacy but to achieve low marks. In a classroom situation learners may have relatively high self-efficacy in respect of a specific task but a negative outcome expectation as a result of certain factors, like wanting to impress their parents but not trusting that they will do well. However, Pintrich and Schunk (1996) still state that a student's self-efficacy beliefs are likely to be highly related to the outcomes.

Should learners continue to do well in their academic activities the likelihood is that they will develop self-efficacy and become more interested in scholastic activities. On the other hand, those from disadvantaged backgrounds become less interested and, ultimately, they disengage from any scholastic activity as a result of the fact that they perceive themselves as failures. Pintrich and Schunk (1996) concur with this point of view when they maintain that learners with low self-efficacy and low outcome expectations may show resignation, and apathy as well as an unwillingness to participate in classroom activities. On the other hand, learners with high self-efficacy tend to persist with a given task even though the task may be difficult and beyond their comprehension.

Schunk (in Zimmerman, Bandura & Martinez-Pons, 1992:665) argues that students with high self-efficacy display persistence, effort and an intrinsic interest in learning. The performance level of self-efficacious learners is high and it becomes relatively easy to teach them. They are also always willing to participate in classroom activities. Notwithstanding the fact that Science/Applied Science is perceived as a difficult subject learners with high self-efficacy will do well as they will tend persevere even if they feel that things are becoming difficult.

Parents have dreams about their children and, at times, these dreams may be in conflict with their children's aspirations. Similarly, when it comes to their children's scholastic achievements and prospective careers parents influence their children. This is because parents have aspirations for their children and these aspirations influence their children's goals. Zimmerman et al (1992) agree that parental aspirations do affect their children's achievements. Kiemanesh (1998:1) argues that "a student's home environment can be seen as an agency that aids in the construction of the student's attitudes and school achievement".

It may be that the academic goals which a parent sets for his/her child are higher than the goals which the child sets for him/herself and this factor may impede the scholastic achievement of the child (Zimmerman et al, 1992). Parents may have higher goals for their children but without taking into consideration the children's aptitudes. In some instances parents want their children to follow in their footsteps. If a parent is a doctor the parent may wish for his/her child to become a doctor despite the fact that the child has no passion for the vocation and also no aptitude for it. Parents will be role models to their children because most often than not children look up to their parents. Being a role model is a good thing, provided that positive behaviours are modelled.

It may be beneficial for the sciences if parents were able to motivate their children positively while taking into account their aptitudes and aspirations. Meece (in Schunk & Pajares, 2002:5) state that "Parents who provide a warm, responsive and supportive home environment, who encourage exploration and stimulate curiosity, and who provide play and learning materials accelerate their children's intellectual development". This shows that parents have an extremely important role to play in their children's learning as the home may be a source of persuasive information which helps guide the children in the right direction.

There are those learners who choose certain subjects at school simply because they want to pursue specific careers. It then follows that it is essential that these learners have a high self-efficacy in respect of the subjects they have chosen if they are to attain their set goals. This high self-efficacy is necessary in order to maintain high academic standards (Pajares, 1996). Should a learner do well in a particular subject this will mean that high self-efficacy is fostered and this, in turn, will breed success in the subject and raise the learner's grades. High academic self-efficacy results in high academic performance which means that when such learners are given a task, the chances are they will execute the task with relative ease.

If a learner wishes to become an engineer then that learner will have to take physical science and mathematics at high school as two of his/her subjects. This implies that the goal of becoming an engineer which has been set will have to be realised and this will be influenced by the development of self-efficacy beliefs which, in turn, will influence academic performance (Pajares, 1996:554). Pintrich and Schunk (1996) argue that, although there are social aspects to career choices, self-efficacy also plays a vital role, and, hence, different gender career choices. This implies that those women are efficacious only in respect of those careers which are traditionally followed by women and that they feel inefficacious in respect of the traditionally male careers.

Schunk (in Schunk & Pajares, 2002:5) states that "observing similar others succeed can raise observers' self-efficacy and motivate them to perform the task if they, too, will be successful". If, in a science class, some learners succeed in solving problems and other learners observe this, then the latter may emulate the former and do likewise. Conversely, if learners observe other learners fail in their performance of tasks, then this may result in the former not believing that they are capable of succeeding and this may dissuade them from executing such tasks. Modelling plays an important role as learners like to see others learners succeed. They will then often follow suit.

When learners are together they talk and discuss ideas and this may influence the choices they make. Peer groups promote motivational socialisation (Schunk & Pajares, 2002:6). This social motivation will be influenced by the type of group with which a learner is associated. If learners are affiliated with highly motivated groups they tend to act in a positive way and this will continue throughout their school careers (Schunk & Pajares, 2002). When learners with good grades go to high school and they associate with highly academically orientated learners they usually achieve better results than learners who associate with less academically orientated peers (Schunk & Pajares, 2002).

Peer pressure plays a role in influencing learners' behaviour, especially at secondary school level, and, thus, if learners mix with the 'right' crowd this could be of benefit to them as there could be positive spinoffs from their associations. Despite belonging to a group learners need autonomy so as to enable them to make their own decisions. In a science class positive peer pressure may be an advantage as, at times at high school, there is less attention from the teachers.

At primary school level a teacher teaches all the subjects in a particular grade and, thus, learners become attached to their teachers. In fact, the relationship between the learners and their teacher may become as strong as a parent-child relationship. When learners go to high school they move into a new and strange world in which they encounter, among other things, competition, less teacher attention and a different teacher for each subject. For less academically oriented learners competition often has a negative effect and results in their not liking school.

As learners enter high school they meet new learners from other primary schools and, for a while, this may make them feel less at home in the new environment. At high school there is more competition than at primary school and the high school environment will emphasise normative assessment (Schunk & Pajares, 2002). These factors may all result in a decline in learner self-efficacy especially in respect of those learners with a low academic orientation.

Learners with a low academic orientation often need individual attention which tends to be lacking at high school level. In order to increase their self-efficacy learners need to be motivated by their teachers and this could be extremely helpful in the science classes at high school level. Learners with high self-efficacy tend to believe that they are capable of executing even the most difficult tasks. If every science/applied science learner could have this same belief they would be better learners and would able to achieve better results.

Research has reported that boys tend to be more confident than girls in subjects such as mathematics, science and technology despite the fact that these achievement differences are diminishing or have, indeed, disappeared (Schunk & Pajares, 2002:10). There is little evidence of differences in the self-efficacy of elementary-aged children (Schunk & Pajares, 2002:10). These self-efficacy differences become more pronounced at high school. However, if teachers were to give prompt feedback to learners after activities or tests then there is a chance that the perceived knowledge gap in Science and Applied Science may close.

- Utility value

The motivation of a person to execute a given task is based on two factors – a high expectation of success or the way in which the task is valued (Ormrod, 2008). If a person believes strongly that a direct benefit will accrue from the task he/she performing then there is a good chance that he/she will endeavour to perform the task well. Even at primary school level learners are happy when they are engaged in activities which they enjoy. Learning under duress is not positive and saps much of the learner's energy.

Within expectancy-value theories (Ormrod, 2008) utility value, along with attainment value, intrinsic value, and cost value, is considered as one component of task-value. Utility-value refers to the perceived instrumentality or degree of perceived usefulness of the present task to future goals. Learners will assign a high value to certain activities if these activities are a means to desired goals. Utility value is, thus, determined by "how well a task relates to current and future goals" (Pintrich & Schunk, 1996; Eccles & Wigfield, 2002:12).

A task may have positive value for an individual because that task facilitates the attainment of important goals such as career goals. This may be true even if the individual is not interested in the activity for its own sake and does not experience intrinsic satisfaction in performing the task (Ryan & Deci, 2000).

Utility value predicts academic achievement (Eccles & Wigfield, 2002). Weiner in (Eccles & Wigfield, 1992:7) argued that expectations of success greatly influence an individual's choice of subsequent achievement. This may play a role in the science/applied science stream selection. For instance, Wigfield, Anderman, and Eccles (2000) found that children's overall task values are significantly related to adopting a mastery orientation (i.e. trying to master the task) and to holding a performance-approach orientation (i.e. maximising favourable evaluations of one's competence compared with others). This implies that the perceptions of the learners about sciences/applied sciences, and the manner in which they behave towards these tracks, might be linked to the utility value of the subjects.

Parents with high cultural capital often pressurise their children to follow in their footsteps, and this may be a good thing. However, children sometimes find themselves in a dilemma if their parents wish them to study a subject they do not like. This may engender anxiety and result in the learners not performing well in the tasks set. Eccles and Wigfield (2000:158) concur by hypothesising that when parents have overly high expectations and place too much pressure on their children, high anxiety emerges. When parents exert too much control over their children these children are more likely to remain extrinsically motivated (Wigfield & Eccles, 1992:29).

Learners engage in activities if they perceive that there are future goals related to these activities. Accordingly, learners may complete certain tasks because these tasks are important for future goals (Wigfield & Eccles, 1992:16). This may be applicable to science/applied science if teachers inform learners about the benefits of doing science/applied science at school. This would mean that, even if learners view science/applied science as difficult, they would take the subject as a way of pursuing their future goals. Wigfield and Eccles (1992) found that learners' expectancies predict their performance in mathematics, English and also in science/applied science. This implies that, if learners expect that it will be possible for them to find better jobs if they pursue science/applied science, then this factor may predict their performance in science /applied science.

Since learners' expectations of success predict their science/applied science performance, it is, therefore, essential that learners be informed of the usefulness of science/applied science to enable them to shrug off the perceived difficulty of the subject. The utility value of science/applied science will predict that high school learners continue to take science/applied science (Wigfield & Eccles, 1992).

In view of the usefulness that boys attach to science/applied science they tend to exert themselves more as compared to girls, who are inclined to doubt their ability even though they may achieve better grades than the boys (Wigfield & Eccles, 1992). These beliefs and attitudes in respect of science/applied science predict gender enrolment in these subjects especially at high school level. Although girls may be aware of the usefulness of science/applied science in terms of future goals they may avoid taking the subject because of their attitude towards the subject. Females tend to believe that it takes more effort to do well in science/applied science and that the sciences are more difficult than other subjects (Wigfield & Eccles, 1992).

Teachers have a pivotal role to play in respect of learning. This is borne out by Moos (in Eccles & Wigfield, 2000: 220) when he states that, “quality teacher-student relationship provides the effective underpinnings of academic motivation and success”. The role of the teacher affects the future aspirations of learners and the way in which they perceive education. In their respective fields of excellence teachers should be agents of change and they should show learners the path to the futures they desire. When teachers have high expectations of their learners and the learners, in turn, perceive these expectations these learners tend to achieve more and also to develop a greater sense of competence (Eccles & Wigfield, 2002). This may be applicable to science/applied science.

If a teacher communicates expectations to learners the learners tend to strive to realise these expectations. These expectations may also be internalised and may help enhance feelings of self worth and achievement (Eccles & Wigfield, 2000). In classes in which the teachers praise the learners when the learners do well, these teachers increase learners’ self-concept and this may be extremely helpful in science/applied science. Frequent use of hands-on learning opportunities, careful monitoring so that all children are given the opportunity to participate, and the use of applied problems to teach basic concepts will all stimulate the interest of students in mathematics and science/applied science (Wigfield & Eccles, 1992:31).

The above are all possible if the teacher is caring and has a high sense of teacher efficacy. If a teacher has a good command of his/her subject it will be relatively easy to be enthusiastic and this enthusiasm will ignite the learners’ own enthusiasm. A high sense of teacher efficacy will enhance the belief of the learners in their ability to master the academic material while, conversely, low teacher efficacy will result in feelings of incompetence on the part of the learners (Eccles & Wigfield, 2000). It has been known for teachers to treat learners differently based on issues such as race, gender and social class (Eccles & Wigfield, 2000) and such behaviour on the part of the teacher may cause learners to "run away" from the science/applied science stream.

- Motivation theories

The term motivation is derived from the Latin verb *movere* (to move) (Pintrich & Schunk, 1996:5). Reiss (2004:179) argues that motives refer to the reasons people hold for initiating and performing voluntary behaviour. Motives always affect an individual's perception, cognition, emotion, and behaviour (Reiss, 2004). According to Pintrich and Schunk (1996:5) motivation is the process whereby goal-directed activity is instigated and sustained.

Ryan and Deci (2000:69) contend that motivation involves energy, direction, persistence and equifinality - all aspects of activation and intention. Pintrich and Schunk (1996) argue that it is not possible to observe motivation directly but that motivation may be inferred from such behaviours as choice of tasks, efforts and persistence in terms of the work being done. Aristotle (in Reiss, 2004) divided the motives for performing a task into two, that is, ends and means. Ends are indicated by engaging in an activity for no apparent reason other than the desire to perform that activity – intrinsic motivation. Means are indicated by engaging in a task for its instrumental value – extrinsic motivation. These two types of motivation as well as self-determination theory will be discussed below.

a) Intrinsic motivation

Intrinsic motivation refers to the motivation to engage in an activity for its own sake (Pintrich & Schunk, 1996). Hunt (in Pintrich & Schunk, 1996:248) argues that intrinsic motivation gives rise to exploratory behaviour and curiosity and that it stems from an incongruity between prior knowledge and new information. Learners wish to reduce the incongruity in any given task so as to understand the task. This is similar to what happens in cognitive dissonance as learners try to find equilibration.

Ryan and Deci (in Bateman & Crant, 2002:3) further purport that intrinsic motivation, which derives from within a person or from the activity itself, has a positive effect on behaviour, performance, and well-being. Intrinsically motivated people demonstrate greater interest, excitement, and confidence, which, in turn, manifests as enhanced performance, persistence and creativity (Deci & Ryan, 1991). Learners who are intrinsically motivated work on tasks because they find these tasks enjoyable. Intrinsically motivated learners would be of benefit to science/applied science because such learners would enjoy performing given tasks and would probably execute these tasks to the satisfaction of the teacher.

Reiss (2004:182) concurs when stating that people are motivated to engage in activities which they expect to experience as pleasurable. Deci and Ryan (in Reiss, 2004:182) are in agreement when they state that "when people are intrinsically motivated, they experience interest and enjoyment, they feel competent and self determining, they perceive the locus of causality for their behaviour to be internal, and, in some instances, they experience flow".

Weiner (in Reiss, 2004:182) shares the same sentiment when defining intrinsic motivation as a source of motivation arising from the enjoyment of an activity. Ryan and Deci (2000:70) suggest that choice, acknowledgement of feelings and opportunities for self-direction enhance intrinsic motivation because they allow people a greater sense of autonomy. If learners were given autonomy in a science/applied science class then the chances are they would fare better in this stream.

b) Extrinsic motivation

Extrinsic motivation is at play when an individual undertakes a task in order to gain an award or to avoid punishment (Yang, Zhang & Wang, 2009). When students study a subject (physical science) merely in order to obtain high marks they may be said to be extrinsically motivated. Ryan and Deci (2000:71) concur as they define extrinsic motivation as the performance of an activity in order to attain some separable outcome. Pintrich and Schunk (1996:245) describe extrinsic motivation in terms of a person engaging in an activity as a means to an end. If learners study hard in order to avoid punishment or in order to receive either a reward or praise from the teacher, they may be said to be extrinsically motivated (Yang et al, 2009). It may happen that learners could be studying science/applied science in order to follow a certain career although they might not be interested in the subject per se.

- *Self-determination theory*

Deci (in Pintrich & Schunk, 1996:257) defines self-determination as the process of utilising one's will. Shroff and Vogel (2009) explain self-determination as the capacity to choose and to have choices. Reeve et al (2003) classify a self-determined person as a person who acts out of choice rather than obligation or coercion. If learners choose science/applied science without any coercion – with volition – the chances are they will fare better than if they had been coerced into taking science/applied science. Ryan and Deci (2000:70) suggest that feelings of competence would not enhance intrinsic motivation unless accompanied by a sense of autonomy.

Ryan and Deci (2000:70) further state people must not only experience feelings of competence or efficacy, but that they must also experience their behaviour as self-determined if intrinsic motivation is to be in evidence. Self-determination requires people to accept their strengths and limitations, to be cognisant of forces acting on them, to make choices, and to determine ways to satisfy needs (Pintrich & Schunk, 1996:257). Shroff and Vogel (2009:61) maintain that, in terms of self-determination theory, individuals have a psychological need to feel competent, self-determined, and related.

The need for competency involves the need to feel that one is able to produce desired outcomes reliably. This implies that one has to be aware of the relationship between behaviour and outcomes. Learners need to know that they have a choice to engage in activities as this allows them to feel that they have autonomy. If learners feel they have autonomy and choice they will feel unpressurised to engage in activities (Shroff &Vogel, 2009).

2.4.2 Teacher factors

2.4.2.1 Social and cultural influences

The influences emanating from society play a pivotal role in learners' choice of certain subjects at school. Most learners choose to do either physics or chemistry because they were advised to do so by their teachers and parents (Fenemma, 1990; Hoffmann-Barthes et al, 1998). In many rural areas there are virtually no role models for children to emulate and this further exacerbates the problem of subject choices (Reddy, 2005). Traditionally there are subjects that society perceives as masculine subjects, i.e. woodwork, metalwork and the sciences, and others, such as home economics and child-care, which are referred to as feminine subjects (Fennema, 1990).

Boys are more exposed to science/applied science related activities at an early age as at home they tend to fix mechanical and electrical appliances, which is something girls rarely do (Blosser, 1990). It also became clear that, while young men did not strongly stereotype mathematics as a male domain, they did believe more strongly than young women that mathematics was a more appropriate subject for males than for females (Fennema, 1990).

In the work environment there are usually more males than females to be found in the fields of engineering, architecture, plumbing and medicine as it would appear that women tend to concede that these are male spheres and they allow males to dominate these spheres (Hoffmann-Barthes et al, 1998). Teachers treat girls differently to boys and they usually expect boys to obtain higher marks than girls in the science subjects. Fennema (1990) suggests that it is relatively easy to identify differential teacher interaction with boys than with girls – boys are both praised and scolded more than girls and boys are called on more than girls to answer questions in class.

Boys and girls approach science problems differently because of the way in which they perceive these problems. Hoffmann-Barthes et al (1998) suggest that teenage boys are more interested in completing mathematical exercises than understanding the techniques being practised while girls, on the other hand, are more concerned with understanding than with completing the work in a short space of time. This illustrates a difference in the way in which the genders approach contextualised problems within a class situation. Textbooks perpetuate the idea of science as a masculine subject because almost all books contain pictures of male scientists while most of the laws of physics which are studied at high school were discovered by male scientists (personal observation). In terms of the sciences students rate physics as more masculine than chemistry and chemistry as more masculine than biology (Hoffmann-Barthes et al, 1998).

2.4.2.2 *Teacher attitudes and their influences on learners*

Kiefer (2004:1) reports that learners chose science because their teacher made it interesting and their teacher puts a lot of effort into teaching. In Kiefer's report one learner commented: "I have a very good teacher who makes it fun and he helps to explain problems to the students individually and works with them until they understand". However, it was also found that, at times, it was the teachers who were influencing learners in a negative way. It is alarming to find primary school teachers perpetuating gendered ideologies in their classes (see Bhana, 2005).

Research suggests that hormones are one of the factors that differentiate boys to girls in terms of science, as male testosterone is seen as the hormone that gives boys leverage over girls (Kleinfeld, 1998). However, in terms of the above assertion, the Grade 2 teacher stated above seems to believe that brain function is more important than hormones. This scenario shows that gender identification begins at an extremely early stage (Bhana, 2005). In view of the fact that learners regard their teachers as role models it is not surprising that teacher attitudes impact on learner preferences for a particular subject.

2.4.2.3 *Opportunities to engage in activities*

Piaget states that there are four stages of child development with the ultimate stage being formal operation. Although all these stages are important it is essential that, learners, as they study further, reach the formal operation stage at which it is stated that they are able to use abstract reasoning. Learners at secondary school level, especially in the higher grades, should be at the formal operation stage, which would, in turn, be extremely helpful in terms of studying science. Nevertheless, Mwamwenda (in Nieman, Kamper & Pienaar, 2008:93) disagrees that all high school learners are at the formal operation stage when he states, “many secondary school learners in Africa are possibly still at the concrete operational level, instead of the formal operational level”. It, therefore, follows that science teachers should concretise science so as to enhance the understanding of learners and, thus, enable them to move to the abstract level of formal operation.

Teachers should allow learners to use science equipment by conducting the experiments themselves instead of observing demonstrations. This, in turn, may awaken their curiosity and encourage them to want to explore science further. When learners are given a problem teachers should encourage them to solve the problem by themselves as this will encourage discovery learning (Nieman, Kamper & Pienaar, 2008). As learners are busy solving problems they will be thinking at different levels. Science teachers must ensure that they teach their learners critical thinking skills, creative thinking skills and problem solving skills. This is synonymous with Critical Outcome 1 (see DoE, 2003:2).

2.4.2.4 Teaching styles

Most often than not, science, applied science and mathematics classes are teacher centred with formal pencil and paper testing as the predominant method of assessment, particularly at secondary school level (Boaler et al, 2000). This evidence reflects negatively on the style of teaching of the teachers concerned. In South Africa, despite the fact that there is provision in the OBE curriculum for a learner-centred approach to teaching, there are schools in which a teacher-centred approach, which is also characterised by rote learning, is the norm (Gaigher et al, 2006). Evidence from previous research suggests that a teacher-centred approach to teaching may result in learners' feeling that they do not have any control over the subject which they are learning. This type of approach may also result in the development of negative attitudes.

Furthermore, in some schools, teachers require learners to do individual work which may be a problem if a learner is experiencing difficulties in the subject (Boaler et al, 2000). The independent seatwork strategy has been shown to discourage certain learners from taking mathematics and science classes. Fenemma (1990) believes it is preferable for teachers to use cooperative learning because most learners thrive during collaborative activities. Fraser (2006:7) shares Fenemma's point of view when he states that "Conceptual growth comes from the negotiation of meaning, the sharing of multiple perspectives and the changing of our internal presentation through collaborative learning". This implies that teachers should use a cooperative learning strategy which would allow learners to engage in meaningful debates about concepts and, thus, enhance their understanding. Hirsch (2001) suggests that the promotion of learner autonomy is one way in which to encourage interest in the curriculum. In terms of the South African context there is scanty evidence showing the correlation between different teaching approaches and the decisions of learners to select a specific subject stream. Nevertheless, the issues raised above suggest learner autonomy to choose subject streams might be important.

Kiefer (2004) states that learners perceive mathematics and the sciences as subjects with obvious right and wrong answers, which a learner may check for him/herself. According to Kiefer (2004) learners are of the opinion that all they have to do is to reproduce what they have been taught and that no understanding is required in order to obtain good marks in science and mathematics. When such learners realise that they were labouring under a misconception they become demotivated in terms of both mathematics and science. Thus, it is clear that either learner expectations or success at school and the way in which they are taught impact on their decision to pursue a particular curriculum at school level.

There are different approaches to, or styles of, teaching in SAS. Gagne (in Watts, 1991:7) argues that problem solving is one such approach. Problem solving allows learners to discover things for themselves and to engage in the solving of problems (Mahaye & Jacobs, 2004:199). This, in turn, may be a source of motivation for learners (Jacobs, 2004). Critical outcome one (CO 1) clearly states that “learners must be able to identify and solve problems and make decisions using critical and creative thinking” (DoE, 2003:2). Thus, the problem solving approach supports required curriculum outcomes within the South African context.

Watts (1991) suggests that problem solving may trigger an interest in a subject in that, during a problem solving activity, learners learn through self-activity. Problem solving enables learner to take ownership of their learning, and it provides a real life context, encourages decision-making and enhances communication (Watts, 1991).

Hobden and Maloney (in Gaigher et al, 2006:16) assert that, in general, physics teachers accept that problem solving leads to an understanding of physics but, according to Van Heuvelen, (in Gaigher et al, 2006) in most cases physics learners tend to be passive as the teacher demonstrates the algebraic aspects of solving problems. The main idea behind problem solving is to make learners solve the problems given to them logically and be able to explain their solutions with conviction. A lack of opportunities for problem solving will discourage a learner from taking a specific subject (WCDoE, 2000; Gaigher et al, 2006).

Cooperative learning is another teaching strategy which is associated with the generating of a high level of interest among learners in a particular subject. In terms of cooperative learning, learners work in small groups in order to realise a common goal (Ormrod, 2008:437). Their interaction is characterised by positive goal interdependence with individual accountability (Johnson & Johnson, 1988). Gawe (2004:211) asserts that, in cooperative learning, learners construct their own knowledge through social negotiation. It is recommended that a group comprise four to five learners. Johnson and Johnson (1995:1) and Johnson, Johnson and Karl (1991:2) state that "cooperating is about working together to accomplish shared goals". It is clear that cooperative learning, as a teaching strategy, would contribute to motivating learners.

Nevertheless, learners within groups may sometimes be competitive rather than cooperative. According to Johnson and Johnson (1993) competition is characterised by negative goal interdependence in terms of which one learner wins and the other loses. This is one aspect of the cooperative strategy that may discourage some learners from pursuing a particular discipline.

It is recommended that groups be heterogeneous in terms of the learners' levels of intelligence to enable group members to assist each other (Johnson & Johnson, 1988). Heterogeneity within a group means that a learner, who may otherwise have avoided a specific subject, may opt for that subject because of the possibility of receiving assistance from others. Vygotsky would say that a knowledgeable learner should assist other learners so as to close the knowledge gap (Tudge, 1997). This is certainly true within a cooperative setting as the more knowledgeable members of the group will assist the less knowledgeable learners until equal understanding has been reached (Johnson & Johnson, 1997). Teachers have a huge role to play in ensuring that cooperative learning takes place.

2.4.2.5 Teacher qualification

After 1994 a concerted effort was made by the government to reduce the number of unqualified and under-qualified teachers (Shiendler, 2008). Before 1994 just over a third of all teachers were either unqualified or under-qualified but, by 2002, this figure had been reduced to 16 percent (Shiendler, 2008). Although a qualified teacher is not necessarily an expert and someone who is able to produce good results so many unqualified teachers was disastrous for the education system. In many cases the educators in South Africa may be the victims of their own education and they may teach in the manner in which they were taught (James, Naidoo & Benson, 2008: 2). Stears and James (in James et al, 2008) argue that some teachers never learnt huge chunks of information when they were learners themselves which means that they struggle now when they have to teach the subject. This is extremely relevant as it is not possible to teach what one does not know oneself.

In order for teachers to know what they have to teach it is essential that they undergo professional development in the form of in-service training. James et al (2008) assert that quality science educators will result in more students entering the tertiary field of science. Teacher professional development may take various forms including individual development, continuing education, peer coaching and mentoring. During professional development teachers may be given the opportunity to learn new teaching techniques in line with the new curriculum (NCS).

2.4.3 Practical work in science/applied science

According to Hayward (2003) all sciences have an essentially practical basis. In the three learning outcomes in physical science Learning Outcome one (LO 1) emphasises skills as physical science is about practical science inquiry and problem-solving skills (DoE, 2003:13). Hayward (2003) argues that practical work helps learners to understand facts and concepts as well as encouraging active learning. This gives learners confidence rather than always having to rely on the teacher.

Hayward (2003) further states that practical work helps to develop cross-curricular skills such as communication, literacy and Information communication technology. Nevertheless, there are various inhibiting factors regarding the carrying out of practical work. The reasons provided by teachers for not doing practical work falls into three categories – lack of facilities, time pressure and class size (Hayward, 2003). A lack of resources means that some schools resort to worksheets which do not enable the learners to learn real science.

At the 1996 National Research Council it was discussed that teachers should move beyond worksheets and step-by-step procedures in order to engage learners in inquiry (Huber, 2007:79). Researchers have shown that there are risks associated with an over-reliance on worksheets and textbooks (Huber, 2007:79) which indicates that teachers should think extremely carefully before planning for an investigation task.

Research has found that teachers are of the opinion that practical work stimulates interest and enjoyment, teaches laboratory skills and the processes of science, and assists the learning of scientific knowledge (Webb, 2007:51). However, despite the fact that teachers feel that practical work should stimulate the interest and enjoyment of learners, this is not necessarily the way learners feel. At high school level practical work is used mostly to endorse the theory that learners have been taught, and it thus becomes questionable as to what the reason is for doing practical work.

In order for learners to be productively involved in practical work it is essential that they have some skills such as measuring, and constructing tables and graphs. These skills would have to be taught beforehand. Other skills used during practical sessions include making observations, taking measurements, handling data, and drawing conclusions (Hayward, 2003).

Science policy documents do specify that practical work should be the cornerstone of science in order to enhance the learners' understanding (DoE, 2002). Teachers who perceive learners as non-destructive are more likely to engage learners in higher level practical work (Hattingh, Aldous & Rogan, 2007:84).

Schools differ in terms of support and innovation. Nevertheless, in well-functioning schools which are characterised by a high degree of innovation practical work tends to take the centre stage and it is performed at a higher level (Hattingh et al, 2007). In some instances there is a reciprocal effect in respect of practical work because motivated learners may have a positive effect on their teachers who may, in turn, provide their learners with the opportunity to engage in interesting, hands-on science (Hattingh et al, 2007).

In most cases a lack of physical resources such as laboratories and science apparatus are viewed as impediments. However, motivated teachers will find a way of doing practical work even in those schools with virtually no resources (improvisation). Conversely, unmotivated teachers will not do practical work even if they have the best resources possible at their disposal (Hattingh et al, 2007: 84).

2.4.4 Teacher-learner relationship and classroom atmosphere

Learners learn better in a warm, conducive environment. It is incumbent on teachers to create this welcoming environment as effective learning under duress is not possible. High school teachers differ from primary school teachers in terms of leniency and kindness. Consequently, learners coming from primary to secondary school perceive school in another way as not what it was at primary school. Midgley, Feldlaufer and Eccles (1989) concur when they state that students at high school level perceive high school teachers as less friendly than the teachers at primary school level.

Observers reported that seventh grade junior high school mathematics teachers were less warm and supportive than sixth grade elementary school teachers (Midgley et al, 1989). This clearly shows the transition from primary to high school as primary schooling is usually characterised by love, warmth and care while high school often involves the survival of the fittest. Despite the fact that this may affect all learners girls are usually the most affected as, more than boys, they need love and support (Osborne, 2003) which they seldom receive at high school.

If teachers were able to be equally supportive to all learners, the negative attitudes towards certain subjects, specifically science, may be eradicated. Evidence shows that the quality of the teaching of school science is a determinant of the attitude towards school science (Osborne, 2003). In teaching, the way in which the teacher treats the learner (love, care or hate and contempt) is of supreme importance – the positive treatment of learners will produce desirable results while the opposite is equally true.

Furthermore, in most schools classroom management is a deciding factor as to the way in which learners will progress in their learning. Teachers who succeed in creating and maintaining effective learning situations in their classrooms are good classroom managers (Maphumulo & Vakalisa, 2004:352). Ill-discipline is one of the major factors that impinge on learning. The discipline of learners in a class depends on how well managed a class is. Now that the paradigm has shifted and teachers are no longer omniscient purveyors of information they must become facilitators and they must allow learners to construct their own knowledge. In order for this to happen it is essential that efficient teachers create an effective learning environment by thoroughly planning their lessons. In terms of the National Curriculum Statement (NCS) (DoE, 2003:5) learners have to "demonstrate an ability to think logically and analytically, as well as holistically and laterally". In science/applied science teachers must ensure that their classes are conducive to effective learning in terms of which learners will be engaged in tasks.

A conducive learning environment depends on the preparation of the teacher for every lesson. Maphumulo and Vakalisa (2004:361) state that there are four general classroom management principles –, initial preparation, a participative approach to planning, avoidance of disorder and the creation of an effective classroom climate. If science/applied science teachers are able to apply the abovementioned principles in their classes they will achieve better results and they get the best out of their learners. No learning may be effective without thorough preparation, and, thus, teachers should make it a habit to be efficient, effective lesson planners. In terms of the norms and standards for educators, educators should be mediators of learning. The precursor of the mediation of learning is thorough preparation so that the subsequent learning proceeds smoothly and the learners are able to attain the required goals.

To summarise, there are various factors that influence the decisions of learners to opt (or not to opt) for the science/applied science stream. Based on the discussion above it is clear that when the language of instruction, for example, English, is not the mother tongue of the learners, then the learners are at a disadvantage because they are faced with the challenge of relating to the concepts used. Social and cultural stereotypes also play a role as learners come from societies with different perspectives on education. The school environment also has an effect as girls tend thrive better than boys in a cooperative environment as opposed to a competitive environment. Fear, anxiety, self-efficacy and the utility value of a task also have an effect on the learners' subject choices, especially in respect of the science/applied science curriculum stream.

2.5 EFFORTS TO PROMOTE SCIENCE AND TECHNOLOGY IN SOUTH AFRICA

2.5.1 The Dinaledi Project

The White Paper on Education and Training (1995) outlined clearly that the imbalances of the past in the education of both science and mathematics had to be redressed. Specific initiatives were needed to produce learners in those subjects which were in short supply (Masehela, 2005:21), including science and mathematics. There were extremely disturbing indicators at this time, namely, only one in five black learners chose physical science and mathematics in standard eight (Grade 10) and performance in the senior certificate examinations was low overall with particularly dismal matriculation exemption rate among learners taking subjects on higher grade (Masehela, 2005:21). This, in turn, meant that there were fewer black learners who were eligible to register for qualifications in mathematics and science at higher institutions.

The need for intervention in Science and Applied Science became evident as the country experienced huge shortages of skilled workers on the one hand, and high levels of unemployment among unskilled workers or work-seekers on the other (CDE, 2004:6; Cohen, 2005). It became clear that it was the African population who was the most disadvantaged and that a programme was needed to enable the full participation and performance of blacks in mathematics and science/applied science (Reddy, 2005). Accordingly, in 2001 the National Department of Education developed a national strategy which was designed to improve participation and performance in both mathematics and science education and the Dinaledi programme was conceived (Reddy, 2005; CDE, 2004).

In order to bring about a change in the *status quo* initiatives were put in place, for example, 102 schools, termed the Dinaledi schools, were selected for a science and mathematics programme (CDE, 2004; Masehela, 2005; Bernstein, 2007). These schools were to be a catalyst in doubling the number of schools enrolling learners in the higher grade and enabling learners to pass with respectable grades (CDE, 2004) The schools selected were supplied with resources such as books, satellite television and laboratory equipment while mathematics and science teachers were offered special training sessions (Masehela, 2005:22).

2.5.2 Non-governmental organisation involvement

The quantity and the quality of human resources are the most important elements of the science capacity and development of a country (ASSA, 2003). Therefore, in order to attract young learners to pursue science at tertiary institutions, the country needs to be able to offer them challenging and rewarding careers. It was for this reason that many non-governmental organisations came to the fore. Rhodes University in the Eastern Cape started a project in the Faculty of Education which was known as the Rhodes University Mathematics Education Project (RUMEP). When this project started it focused on mathematics at primary school level, but, as the years passed, it also started to focus on high school mathematics (FET phase) (www.ru.ac.za/rumep). This project focuses only on the Eastern Cape and, especially, on the rural schools and farm schools. Under-qualified teachers complete the ACE and B Ed in-service mathematics and physical science education programme which upgrade the teachers' qualifications and enables teachers to become better practitioners by advancing both their pedagogical content knowledge and their subject content knowledge.

In the University of KwaZulu-Natal, a Centre for the Advancement of Science and Mathematics Education (CASME) came into being. It focuses on schools in the KwaZulu-Natal province and helps these schools to achieve better results in science and mathematics. Teachers attend workshops so that they may be better skilled to tackle problematic areas in the curriculum (www.casme.ac.za or www.ukzn.ac.za/casme). Learners are also taken on visits to the university in order to motivate them and to allow them the opportunity to see equipment which is not available in their schools.

Marang Centre for Maths and Science Education functions at the University of the Witwatersrand. This centre focuses on mathematics and science in Gauteng schools. Teachers attend workshops where they receive training in those topics which they find difficult. Teachers also receive training in practical work to enable them to offer their learners the opportunity to do practical work themselves (www.wits.ac.za/education).

There are other institutes that are involved in mathematics and science education, namely, the African Institute for Mathematical Sciences School Enrichment Centre (AIMSSEC) where teachers are able to do Advanced Certificate in Education either in mathematics or in science, the Joint Education Trust (JET) which works with schools and teachers at the FET phase in mathematics and science, the Programme for Technological Careers (PROTEC) which works with schools and teachers in the FET phase with the aim of producing engineers, the Maths Centre for Professional Teachers (MCPT) which works with teachers from the foundation phase to the FET phase. The latter holds workshops and they also conduct follow up class visits. The Zenex Foundation has been involved in several mathematics and science projects and is also involved in the Dinaledi Project into which it injected R10 million in order to improve results in mathematics and science (Zenex Foundation, 2003).

The government has also not been left behind in these initiatives as, in 1996 May, it launched science week. Science week is held in each education district and its main aim is to motivate learners to pursue careers in the fields of mathematics and science. During the science week learners from different schools showcase their experiments while other learners (the audience) are allowed to ask questions. The government also encourages schools to institute science clubs. Once or twice a year each district is expected to hold science camps for Grade 11 and Grade 12 learners.

2.5.3 Bursaries for pursuing SAS careers

Both the business and the private sector are also making a contribution in terms of financing higher education. There are bursaries available for most of the qualifications offered at institutes of higher learning with more bursaries and scholarships being offered for science and science related qualifications (HESA, 2005). Bursaries are awarded on the basis of academic achievement although the financial situation of the applicants is also taken into account (HESA, 2005). There are several companies that offer learners bursaries for science and applied science related qualifications. These companies include Eskom, Telkom, Ernst and Young, Murray and Roberts, Sasol, Kumba Iron Ore and Transnet (HESA, 2005). However, most of these companies offer bursaries for engineering qualifications.

In addition, the government also offers bursaries, for example, the Department of Minerals and Energy offers science and applied science related bursaries (www.dme.gov.org.za). The latter is evidence that the government is promoting the science and applied science stream. The Department of Education is also offering bursaries for those learners who want to join the teaching profession, especially learners who intend to major in science and mathematics (www.doe.gov.org.za). The aim of the latter is to increase the number of science and mathematics teachers, which would, in turn, increase the number of learners in the science and applied science stream.

2.6 SUMMARY

This chapter covered a wide range of issues that influence learners' decisions in respect of the science/applied science stream. The literature reviewed raised cultural and social issues in terms of which stereotypes play a vital role in subject selection at high/secondary school. Furthermore, teaching styles, teacher attitudes and classroom management were discussed as well as the role they play in the subject selection of learners.

Teacher qualifications and the effect on the teaching of the subject matter were also discussed as a lack of content knowledge would probably have a negative effect on learners as teachers would not show any enthusiasm in their teaching. Another well documented inhibiting factor is the language problem especially for those learners whose home language is not the medium of learning and teaching.

However, literature fails to offer any explanations as to the reasons why learners opt not to select SAS even if they have the ability to do well in these subjects. Literature also does not cover the intentions of learners to opt (or not to opt) for SAS as early as grade 9 as studies were conducted after the choices had been made and it was not possible to do anything to change the *status quo*.

Within the South African context the deterrents in respect of SAS stream selection in the rural areas is not an area which has been explored in the local literature. The literature in the United States of America, for example, indicates that race, ethnicity, and social class do play a role in stream allocation. However, within the South African context which is characterised by an emphasis on redressing past racial discrimination and inequalities in education, it is not yet clear whether the issues of race and/or gender influence learners in respect of subject stream selection, whether the learners themselves do have genuine freedom of choice or whether the word "choice" is used merely to reflect the "right thing to say". The literature is silent on these and related concerns, which in turn, provides a basis for the research problem outlined in chapter 1. This research strives to address the core question in respect of those factors which influence the learners' intentions to select the Science and Applied Science curriculum stream and also the demographic characteristics associated with the aforementioned factors within the South African context. According to the literature this aspect has not yet been the focus of research.

The next chapter discusses the research methodology utilised in this study.

CHAPTER 3
RESEARCH METHODOLOGY

3.1 INTRODUCTION

The previous chapter reviewed the existing literature on Science and Applied Science (SAS) as well as the SAS curriculum in schools. It also discussed evidence related to the reasons why some learners opt for the SAS curriculum in schools while others disregard it as a field of study. It is clear from the discussion that, within the South African context and in the Amathole District, in particular, evidence on this issue is scanty.

This chapter provides an outline of the research approach and research design which were used to investigate the research problem which was stated in chapter 1. Central to chapter 4, therefore, is an exposition of the study sample, data collection and analysis procedures and the measures taken to access the participants. The post-positivist paradigm is the research paradigm adopted in this study and it involves both qualitative and quantitative methods. Accordingly, the data collection included both questionnaires and interviews. The study was guided by strict ethical measures which are outlined in this chapter. The chapter begins with an overview of the research paradigm.

3.2 RESEARCH PARADIGM

A research paradigm refers to the philosophy behind the research process Fouché & De Vos (in De Vos, Strydom, Fouché, Poggenpoel, Schurink & Schurink, 1998:130). The research paradigm includes both the assumptions and values that serve as a rationale for the research as well as the criteria that the researcher used for interpreting the data and for reaching conclusions (Saunders et al, 2003:340). According to de Vos et al, (1998:12), it is essential that the research paradigm suit the knowledge interest or purpose of the research.

Bearing the abovementioned perspectives in mind the researcher deemed a post-positivist paradigm to be the most suitable paradigm for this research. The reason for this choice stemmed from the fact that a central knowledge interest of the research was to explore, determine and understand the factors underlying the intentions of Grade 9 learners either to select or not to select the sciences/applied sciences as a curriculum stream for Grade 10. At the same time the study also sought to explore and understand the reactions of Grade 9 teachers in respect of the issues explained above. These two foci necessitated a post-positivist approach (Brown & Schulze, 2007).

Within the post-positivist paradigm aspects of both quantitative (positivist) and qualitative (interpretivist) techniques are applied on a phased basis (Saunders et al, 2003:340). In other words, the post-positivist paradigm is characterised by the use of primarily interventionist and decontextualised quantitative methods together with elements of qualitative methods (Brown & Schulze, 2007:6; De Wet, 2007:79). A researcher may decide either to accord both paradigms, qualitative and quantitative paradigms equal status or to make one particular paradigm dominant with the other less dominant. The researcher in this study used the dominant-less-dominant proposal of Creswell. Creswell (in De Vos, 1998:360) developed this dominant-less-dominant framework for carrying out research using the mixed-methods paradigm. In this study the positivist phase dominated while the interpretivist phase was less dominant, since the interpretivist phase was a follow up study.

The two approaches (positivist and interpretivist) characterise complementary components of the research process (De Vos et al., 1998) and the resulting combination results in complementary strengths (Johnson & Onwuegbuzie, 2004:18). For instance, one advantage of combining the approaches in this research was that this enabled the researcher to rely on aspects of the acquired 'meanings' from the qualitative data in order to understand or to interpret the results which had been obtained from the quantitative component. The corroboration of findings across the different approaches improves the confidence in the conclusion(s) reached. However, if, at the same time, there were a conflict in the conclusion(s) the researcher would have the flexibility to modify the interpretations accordingly (Johnson & Onwuegbuzie, 2004). However, there was no conflict observed in the conclusion(s) of this study which, in turn, improved the internal validity of the research (De Vos et al, 1998).

3.2.1 Mixed-methods paradigms

3.2.1.1 Quantitative approach

In quantitative research the researcher uses numerical data in order to test the association or relationship between variables (De Vos, 2005). Numerical data tests validate already constructed theories about the way in which phenomena occur

(Johnson & Onwuegbuzie, 2004:19). The findings of quantitative research may be generalisable if the sample has been randomly selected and also if the sample is representative of the entire population (De Vos, 2005). In this study a representative sample was not drawn but, instead, a non-probability sample of Grade 9 learners was used. This reason for this choice was the difficulty experienced in obtaining a sample frame of Grade 9 learners in the Amathole District. Nevertheless, it is recognised that this sampling approach places a restriction on the generalisability of the findings (Creswell & Clark, 2007).

3.2.1.2 Qualitative approach

Qualitative researchers believe that the world is made up of individuals with their own assumptions, attitudes, intentions, beliefs and values (Nieuwenhuis, 2007). In view of the fact that there are values and attitudes involved it is essential that a qualitative researcher interacts with the respondents. This interaction means that the researcher becomes an integral part of the research process in the qualitative phase. Patton (in Golafshani, 2003) asserts that it is necessary for a researcher to be involved in his/her research in order to record events and to make changes to the research process as events unfolded. In the qualitative phase of the research the researcher collected data by means of interviews – one way of recording events as they unfold.

Qualitative research uses a naturalistic approach that seeks to understand phenomena in context-specific settings (Golafshani, 2003:600). De Vos (2005) assert that data is collected from people immersed in the setting of the everyday life in which the study is framed. In this research teachers who were involved with the

Science/Applied Science curriculum were used as participants because they were directly involved with the phenomenon under investigation. In other words, these teachers were the people who were immersed in the setting of the everyday life in which the study was framed.

3.3 RESEARCH DESIGN

The research design is the blueprint in terms of which a study is conducted (De Vos et al, 1998). Since this study comprised two phases, namely, a quantitative phase and a qualitative phase, a mixed method design was selected for the investigation. This involved a survey for the quantitative phase and a case study for the qualitative phase. The two phases were carried out sequentially (Johnson & Onwuegbuzie, 2004:19). The motivation for each of these two designs is discussed below.

3.3.1 Survey design

In the quantitative phase of this study the aim was to involve as many Grade 9 learners as possible. The survey design enabled the use of questionnaires to reach as many of these Grade 9 learners as possible.

3.3.2 Case study

The teachers of the Grade 9 learners who had participated in the survey were selected as the case study for a follow-up investigation. In view of the fact that the teachers were treated as cases it may be said that a multiple cases strategy was adopted (Yin in Saunders et al, 2003:140). The researcher was interested in understanding the reactions of the teachers to the reasons which the learners had provided for their decisions either to opt, or not to opt, for the Sciences/Applied Sciences curriculum stream. The researcher was also interested in what the teachers might be able to do to help promote interest in this SAS stream.

3.4 SAMPLE AND SAMPLING

3.4.1 Quantitative phase

The sample in the quantitative phase comprised Grade 9 learners in secondary schools in the Amathole district. A total of 346 Grade 9 learners participated in the study. This was deemed a sufficiently convenient sample size to permit statistical analysis. Saunders et al (2003) suggest that a sample size of 100 or more is suitable for statistical analysis if the focus of study is not to generalise. Generalisation was not the focus in this study.

The sample for the quantitative phase was drawn conveniently. Convenient sampling is a non-probability sampling method (Saunders et al., 2003) and it is a sampling procedure which allowed the researcher to use his own judgment in the selection of both the schools and the participants (Saunders et al, 2003). The main criteria for selecting the sample were that the learners be in Grade 9 and that they attend secondary schools within the Amathole District. They also had to have the intention of proceeding to Grade 10.

The secondary schools from which respondents were drawn were selected with great care. The researcher wanted secondary schools in different local geographical contexts within the district. Consequently, schools located in the following three different areas/contexts were targeted – rural village, township and town. The inclusion of learners who attended secondary schools in these different contexts increased the chances of obtaining a wide cross section of reasons for the choices of the learners either to consider opting, or not opting, for the SAS curriculum.

3.4.2 Qualitative phase

Teachers of the Grade 9 learners in the schools in which the survey had been conducted participated. In the qualitative phase, a total of three teachers were selected. One teacher was selected per secondary school. All the teachers were selected conveniently. The main criterion was that teachers had to teach subjects in the SAS curriculum stream.

3.5 RESEARCH METHOD

3.5.1 Access to participants and to the research site

The researcher sought permission to conduct the research from both the District Education Office Director (*See Appendix A: letter asking for permission to conduct the research*) and from the principals at each of the schools selected. These individuals whose permission was sought served as *gatekeepers* (Saunders et al, 2003). The purpose of seeking their permission was to ensure both access to the sites and to the research participants and also to ensure that the provisions in the Departmental research policy were adhered to (see DoE, 2007: research in school Policy). In order to achieve access to the research sites, letters were written and dispatched both to the District Education Office Director and to the principals informing them of the research and soliciting their cooperation. Only once their permission had been secured was the fieldwork mounted (*see Appendix B: Letter from the District Director*).

These gatekeepers were essential because they were the point of introduction between the researcher and the target participants. The gatekeepers helped to remove obstacles such as scepticism on the part of the teachers who may have thought that the research was a ploy to spy on them and also to prevent learners from deliberately giving wrong answers so as to mislead the researcher – both of which would otherwise have inhibited the investigation.

3.5.2 Data collection

3.5.2.1 Instruments

- Questionnaire

The researcher used a questionnaire as the main data collection tool. This questionnaire was used to collect the data necessary to answer the research question (a) to (d) (cf. chapter 1:8). The questionnaire consisted of three parts. The first section covered the background data of participants and included data on the gender and age etc of the participants. The second section covered questions on the attractors and deterrents in respect of the decisions of the participants either to opt or not to opt for the science/applied sciences stream. The final section contained one open-ended question which asked respondents to provide any other reasons which were not asked on the questionnaire. The five point Likert scale format was the scale used in section 2 of the questionnaire. The scale ranged from level 1 to level 5 with level 1 being "strongly disagree" and level 5 being "strongly agree". (*See Appendix C: For questionnaire.*)

In order to draw up the questionnaire the researcher used data from the following two sources. Firstly, an in-depth study of the literature in terms of which a search was conducted of factors relating to the attractors and deterrents. This assisted in the instrument development. Secondly, a preliminary informal conversation with Grade 9 learners in the Amathole district about their reasons for either choosing or not choosing the sciences/applied sciences curriculum stream. The information gathered from this conversation then formed statements on the instrument.

- Pilot testing of the questionnaire

The questionnaire was piloted in one school. A pilot study involves testing the actual instrument on a small sample taken from the community for whom the instrument is planned (Bless, Higson-Smith & Kagee, 2006:60). The reason for piloting the questionnaire was to check issues in respect of problems with language, the clarity of the instructions and the questions, the time taken to complete the questionnaire and whether the instrument had succeeded in generating data to answer the research questions. The piloted instrument was accompanied by an appendix in terms of which respondents were asked to indicate the difficulties they had experienced in completing the questionnaire (see Appendix D for response sheet).

Based on the pilot test three main changes were made to the questionnaire. The question about the respondents' household head was rephrased. New constructs reflecting the respondents' reasons for opting, or not opting, for SAS were added. Finally, questions about the academic performances of the respondents in the Grade 8 final examinations were included. These changes improved the quality of the instrument. The Cronbach Alpha of the instrument was 0.83 which was deemed appropriate.

- Semi-structured interviews

The interview was conducted by the researcher. An interview involves verbal interaction between the researcher and the respondents (Goddard & Melville, 1996; Bless et al, 2006). In terms of this study the interview was semi-structured because, based on those themes which had emerged from the survey, it was a follow up. The themes covered in the interview included: (a) reasons behind intentions to opt for the SAS stream, (b) reasons for not selecting the SAS curriculum stream, (c), learner involvement in practical work and (d) perceived difficulties in the learning of science and applied science.

3.5.3. Data collection

3.5.3.1 Administration of the questionnaire

The data was collected in two phases. In the quantitative phase the researcher visited six secondary schools and administered the questionnaires to all the Grade 9 learners who had agreed to participate in the research. This was done after soliciting their participation in the study via the gatekeepers (see Appendix E: Letter from principal). This process was repeated until 362 questionnaires had been completed. Sixteen of these questionnaires were not completed correctly and were, thus, excluded. Accordingly, 346 questionnaires were used. Participants were asked to complete the questionnaires on the spot. However, if this were not possible the researcher worked in close cooperation with the class teachers at the school to collect the questionnaires within a week of administration.

Six schools were used with four of these schools being co-educational and two single sex schools (one boys' school and one girls' schools). In three of the schools the researcher administered the questionnaire himself. The researcher had the cooperation of some of the teachers for the questionnaires to be completed during class sessions. However, in other instances, the researcher had to use the afternoon after classes had finished for the day. The learners were informed that they did not have to write their names as it was essential that the questionnaires be anonymous for reasons of confidentiality. All other instructions were explained. On average, the questionnaire took 15 minutes to complete.

3.5.3.2 Interview

In the follow up qualitative phase the researcher interviewed teachers after arrangements to do so had been made during the administration of the questionnaires. The researcher kept in touch with the teachers through the gatekeepers. The teachers were interviewed after all details of those factors influencing learners had been ascertained. The following teachers were chosen – one from a coeducation school, one from a girls' school and the other from a boy's school. The school were located in the township and in towns/city. The following key factors were focused upon: (a) reasons behind intentions to opt for the SAS stream, (b) reasons for not selecting the SAS curriculum stream, (c), learner involvement in practical work and (d) perceived difficulties in the learning of science and applied science.

The interviews were conducted at the school where the teachers worked as this was the most convenient location. On average, each interview lasted approximately 20 minutes. The interviews were tape recorded and then transcribed. Permission to tape record the conversations was obtained. One question started the interview process and this was succeeded by follow-up questions. The interviews ended when the main issues of concern had been addressed fully (*see Appendix F: for interview questions and script*).

3.6 DATA ANALYSIS

3.6.1 Questionnaire data

The quantitative data analysis involved a process of data cleaning and data entry into the SPSS programme. The data was first coded and entered into the programme by the researcher. After data entry a preliminary analysis of the data was conducted in order to check the accuracy of the data. Once all errors had been detected and removed, then decisions were made regarding the appropriate statistical measures to be used. The data was analysed using both descriptive and inferential statistics. In terms of the descriptive statistics the frequency, percentage, dispersion, mean and range were calculated while, in terms of the inferential statistics ANOVA tests were conducted. (See chapter 4, page 105-107, for further details).

3.6.2 Interview data

A comparative method of data analysis was used to analyse the interview data. This involved coding and categorising the patterns and themes which emerged from the interview data (Saunders et al, 2003). The scripts were read and reread in order to obtain a sense of what had been said by each interviewee. Once units of meanings had been identified these units of meaning were coded and then categorised into themes. Those aspects which had been discussed in the semi-structured interviews assisted in the final decision about the themes. The themes are presented, together with supporting verbatim, in the presentation of the data in chapter 5. The study supervisor acted as external coder for the interview data.

3.7 QUALITY CRITERIA

3.7.1 Reliability and validity

3.7.1.1 Reliability

Delport (2005:162) asserts that reliability refers to the stability or consistency of the measurement. It is concerned with accuracy and precision (Cohen, Manion &

Morrison, 2000). If a variable is tested under the same conditions then that variable must produce the same result. Reliability is reflected in the fact that an instrument produces the same results each time the instrument is applied (Delport, 2005, Cohen et al, 2000). The Cronbach Alpha value of the instrument in this study was calculated as 0.83 which was regarded as a credible measure of the reliability of the instrument.

3.7.1.2 Validity

Babbie (in Delport, 2005:160) states that validity refers to the extent to which an empirical measure accurately reflects the concepts it is intended to measure. (Also see Cohen et al, 2000). There are two aspects to validity – whether the instrument measures the concept in question and whether the instrument measures the concept accurately (Delport, 2005:160). In order to ensure validity the instrument in this study was given to the study supervisor for examination. Furthermore, the instrument was also piloted to determine its validity. The following types of validity were checked:

- Content validity

This form of validity looks at the instrument and whether the instrument covers all the aspects it is meant to cover. Delport (2005) argues that an instrument is valid if the instrument measures what the researcher is assuming it will measure and also if the instrument represents the sample of items to be measured. In order to ensure content validity the literature review was used and the supervisor for the study, who is an expert in the field, was consulted.

- Face validity

Deport (2005:161) asserts that face validity is concerned about the superficial appearance or face value of an instrument. This simply means that, if the instrument appears to measure the variables it claims to measure, then the instrument has face validity. The supervisor was also consulted in this regard in order to check the face validity which was, indeed, confirmed.

3.7.2 Measures to ensure trustworthiness

Rolfe (2004) argues that the quality issues at stake in qualitative research are different to those in quantitative research. Sandelowski (in Rolfe, 2004:305) argues that issues of validity in qualitative studies should be linked, not to 'truth' or 'value' as they are for the positivists, but rather to 'trustworthiness'. Maree (2007) defines trustworthiness as the way in which the inquirer is able to persuade the audience that the findings are worth paying attention to and that the research is of high quality.

Rolfe (2004:305) further states that trustworthiness is further divided into credibility – which corresponds with the positivist concept of internal validity – dependability – which relates more to reliability – transferability – which is a form of external validity – and confirmability – which is largely an issue of presentation. Lincoln and Guba (in Nieuwenhuis, 2007:80) agree when they assert that the key criteria for trustworthiness are credibility, applicability, dependability and confirmability. These criteria were realised in this study in the following ways: mechanical recording of data; use of the verbatim in the reporting of results; debriefing of the participants. The researcher also provided clear descriptions of what had happened in the field as events unfolded.

3.8 ETHICAL MEASURES

3.8.1 Informed consent

According to Cohen et al (2000:51) the principle of informed consent arises from the subject's right to freedom and self-determination. Strydom (2005) insists that obtaining informed consent implies that all possible or adequate information about the goal of the investigation, the procedures followed during the investigation, the possible advantages, disadvantages and dangers to which the respondents were exposed as well as the credibility of the researcher has been well communicated.

Accordingly, before the study was undertaken, the consent of all the gatekeepers, that is, the District Director and the principals of the respective schools (*See Appendix B: letter from the District Director*) was both sought and granted. The consent of the teachers to allow the learners to participate was also sought (*see Appendix E: Letter from principal).* Participation was voluntary.

In this regard the gatekeepers were informed in detail about what the research entailed and they agreed. The learners also were informed about the purpose of the research and they all agreed to take part in the research. All the learners and teachers involved in this research did so voluntarily.

3.8.2 Anonymity and confidentiality

Cohen et al (2000) stress that the anonymity of research participants should be guaranteed at all times. Accordingly, all the participants were assured of anonymity and confidentiality before the research commenced. A research participant is considered to be anonymous if a reader is not able to identify him/her (Cohen et al, 2000). The schools used were referred as either school A or school B to ensure that the reader was not able to identify them. The questionnaires were answered anonymously so as the retain the anonymity of the respondents. During the interview the respondents were referred to as either respondent one or respondent two from either school A or B to ensure that the respondents would not be traceable. Strydom (2005) stresses that no one, including the researcher, should be able to trace the respondents after the research has been completed.

3.8.3 Deception and privacy

According the Cohen et al (2000:63) deception is involved when the researcher either knowingly conceals the true purpose and the conditions of the research or else positively misinforms the subjects (see also Strydom, 2005). Loewenberg and Dolgoff (in Strydom, 2005:60) describe the deception of subjects as the deliberate misrepresentation of facts in order to make a person believe something which is not true, thus violating the respect to which every person is entitled. The participants were well informed about the purpose of the research. Informed consent was sought and anonymity was assured which meant that privacy was observed and, thus, that no participant could be victimised in any way for having participated in the research. Participants were also informed that they would not be forced to answer any questions that they felt encroached on their human dignity.

Pring (in Cohen et al, 2000:60) argues that the right to privacy is sometimes contracted by the public's right to know. Strydom (2005) defines privacy as that which is not normally intended for others either to observe or to analyse. In this research the participants' right to privacy was respected and the participants were all informed that they had a right not to answer any questions that they felt were sensitive.

3.9 SUMMARY

In this chapter the methodology and the research designs used in this research were explained. The methodologies and instruments used for data collection were also outlined. Ethical issues were discussed and the researcher explained how these ethical issues had been observed in the study. The quality of any research is important and, thus, the researcher alluded to the way in which the quality of this research had been ensured. The research findings will be presented and discussed in the next chapter.

CHAPTER 4

PRESENTATION AND DISCUSSION OF RESEARCH FINDINGS

4.1 INTRODUCTION

This chapter presents the findings of the empirical investigation carried out in this study. The chapter commences with an overview of the specific research questions, and then proceeds to describe the demographic and school characteristics of the sample. Findings related to those factors influencing the learners' intentions to select the Science and Applied Science curriculum stream are also presented together with statistically significant associations between these and the demographic characteristics. The chapter ends with a discussion of the findings.

4.2 SPECIFIC RESEARCH QUESTIONS

The research investigated five specific research questions. Four of these questions focused on Grade 9 learners and their intention to select the Sciences/Applied Science curriculum stream in Grade 10. The other question focused on the reactions of Grade 9 teachers to the issues raised by the Grade 9 learners about their intentions either to select or not to select the Sciences/Applied Science curriculum stream. This last question was framed as a follow-up study. The specific research questions were as follows:

Research question 1: What are the demographic and school characteristics of those Grade 9 learners who intend to opt for the Science/Applied Science curriculum stream in Grade 10?

Research question 2: What demographic and/or school factors in respect of the Grade 9 learners are significantly associated with their stated intentions to opt for the Science/Applied Science curriculum stream in Grade 10?

Research question 3: What are the attractors and/or deterrents influencing the decisions of Grade 9 learners either to opt or not to opt for Science/Applied Science as a curriculum stream?

Research question 4: Is there a significant difference between male and female learners in respect of the attractors/deterrents influencing their decisions either to opt, or not to opt, for the Science/Applied Science curriculum stream?

Research question 5: What are the views of Grade 9 teachers regarding the issues raised by learners in respect of *research question 3* above, and the implications of these attractors/deterrents for promoting Science/Applied Science as a viable stream?

4.3 STATISTICAL TECHNIQUES

Simple descriptive and inferential statistical methods were used, and incorporated into the SPSS programme for analysing the data. The variables were precoded in preparation for entry into the programme. Despite the fact that the variables were descriptive in nature they were assigned numeric codes to facilitate different statistical analysis. The measurement level of some of the variables was nominal and others ordinal. After the data had been checked the codes were entered into the programme and the process of data cleaning ensued. Appropriate statistical procedures were then performed.

Frequency counts and percentages were applied to the data relating to the demographic and school characteristics of the respondents in order to determine the distribution of gender, age group, racial group, home language, household head and highest level of education of the household head. The school characteristics included the location of the school and whether the school was a single sex or coeducational gender school. The frequencies of those factors either attracting or deterring the respondents in respect of their decisions of whether or not to select the Sciences/Applied Sciences stream were also assessed in terms of percentages to ascertain the distribution across the respondents. A bivariate analysis between the respondents' demographic characteristics and the factors attracting or deterring them in respect of the Sciences/Applied Sciences stream was performed and discussed.

In order to understand the degree of association between the gender of the respondent or the highest level of education of the person with whom they lived, and those factors either attracting or deterring them in respect of the Sciences/Applied Sciences stream, the Chi-square test of association (and, in some cases, the Monte Carlo test) was performed. Where significant values were observed separate analysis of variance (ANOVA) tests and frequency analysis were conducted in order to ascertain where these differences lay. An analysis of variance was also carried out to test for significant differences between the genders of the learners, their performance in the sciences in Grade 8, their intention to select the Sciences/Applied Sciences curriculum stream and those factors that either attracted or deterred them in respect of this stream. The outcomes of these analyses are described in the sections below.

4.4 DEMOGRAPHIC AND SCHOOL CHARACTERISTICS OF RESPONDENTS

The demographic and school characteristics of the respondents are presented in Tables 4.1a, 4.1b, and 4.1c. A total of 346 Grade 9 learners participated in the study. This and other details are presented in Table 4.1a.

Table 4.1a: Demographic characteristics of respondents

Demographic Characteristics	Frequency	Percent
Gender:		
Male	174	50.3
Female	172	49.7
Total	346	100.0
Age group:		
12 years or younger	4	1.2
13 to 15 years	255	73.7
16 years or older	87	25.1
Total	346	100.0
Racial/ethnic group:		
Black	298	86.1
White	28	8.1
Indian	6	1.7
Coloured	14	4.0
Total	346	100.0
Home language:		
IsiXhosa	291	84.1
IsiZulu	3	0.9
English	46	13.3
Afrikaans	6	1.7
Total	346	100.0

The statistics relating to gender in Table 4.1a indicate that there was approximately the same number of female respondents (49.7%) as males respondents (50.3%). The majority (73.7%) of the respondents were in the 13 to 15 years age group which is the age-appropriate range for Grade 9 learners. In view of the fact that the study was conducted in the Amathole District of the Eastern Cape and the Amathole District is a predominantly Black, isiXhosa region, it is hardly surprising that the majority (86.1%) of the respondents were black Africans and that IsiXhosa was the home language of most of them (84.1%). Less than 10% of the respondents were from the white, Indian, or coloured racial groups, and fewer than 14% spoke Afrikaans or English as their home language.

The family characteristics of the respondents are presented in Table 4.1b. Of the 346 respondents over one half (51.7%) either lived with both their mother and father, or with their mother only (27.7%). This statistic is consistent with the Provincial Department of Education Snap Survey data which indicates that the majority of learners reside with their biological parents (DoE, 2006).

Table 4.1b: Family characteristics of respondents

Demographic Characteristics	Frequency	Percent
With whom do you live at home:		
Mother only	96	27.7
Father only	12	3.5
Mother and father	179	**51.7**
Other (specify)	59	17.1
Total	346	100.0
Highest level of education of the person with whom you live:		
Matriculation	68	19.7
Certificate (College)	43	12.4
Degree	91	26.3
Do not know	144	**41.6**
Total	346	100.0

It is interesting to note that, although more than half the respondents live with either both parents or with their mother only, the majority did not know the highest level of education of the person(s) with whom they lived. This may be a result of limited conversation about the issue within the home context. However, among those respondents who did know the highest level of education which had been attained by their household's head(s), the majority (26.3%) lived with family member(s) who had a degree. More respondents lived with family members with matriculation as their highest level of education than those who lived with family members with certificate (see Table 4.1b).

The respondents were drawn from schools located in three different geographical contexts – rural village (tribal settlement/smallholding/farm), township (peri-urban and informal settlement), and town (urban settlement) (see Table 4.1c). This classification is based on how 'remote' the school was, and on the social amenities and infrastructure available in each area (see DoE, 2006). Towns usually have more amenities and a better infrastructure compared to rural villages.

Table 4.1c: School characteristics of respondents

Demographic Characteristics	Frequency	Percent
Your school is located in a:		
Rural village	4	1.2
Township	145	41.9
Town	197	56.9
Total	346	100.0
Your school is a/an:		
All boys' school	88	25.4
All girls' school	80	23.1
Boys' and girls' school	178	51.4
Total	346	100.0

The majority of the respondents attended schools situated either in towns (56.9%) or townships (41.9%) (see Table 4.1c). while slightly more than a quarter (25.4%) of the schools were all boys' institutions. The majority (51.4%) of the schools were coeducational. All the single gender schools were located in towns. The single gender schools were former model C schools which have a history of achieving exceptionally good results in national examinations.

The next section presents the findings emanating from the specific research questions.

4.5 RESEARCH FINDINGS

In this section the data is presented per research questions, starting with research question 1.

4.5.1 ***Research question 1***: What are the demographic and school characteristics of those Grade 9 learners who intend to opt for the Science/Applied Science curriculum stream in Grade 10?

The proportions of those respondents who intend to opt (or not to opt) for the Sciences/Applied Sciences are presented in Table 4.2.

Table 4.2: Proportion of Grade 9 learners intending to opt for the Science/Applied Science curriculum stream in Grade 10

Variable	Responses				Total (%)
	Yes		No		
	F	%	F	%	
Grade 9 learners	198	**57.2**	148	42.8	346 (100.0)

Of the 346 respondents 57.2% indicated that they did intend to opt for the Sciences/Applied Sciences stream in Grade 10. In view of the general perception that the Science and Applied Sciences is a difficult curriculum stream this finding is somewhat surprising as one would have expected (cf. chapter 1) that more learners would decide against pursuing the sciences. Nevertheless, the percentage difference between those who indicated that they did intend to opt for the Sciences/Applied Sciences curriculum stream and those who indicated that they did not intend to pursue that stream is 14.4%, which is not a wide margin.

A bivariate analysis was performed in order both to disaggregate and to gain a further understanding of the characteristics of those respondents who had agreed that they intended to opt for the Sciences/Applied Sciences stream. This data is presented in Table 4.3.

Table 4.3: Bivariate analysis of respondents' demographic characteristics in terms of their responses regarding their intentions to opt for the SAS curriculum stream

Variables		Responses					
		Yes		No		Total	
		F	%	F	%	F	%
Gender	Male	***110***	***63.2***	64	36.8	174	100.0
	Female	88	51.2	84	48.8	172	100.0
	Total	198	57.2	148	42.8	346	100.0
Racial/ethnic group	Black	174	58.4	124	41.6	298	100.0
	White	11	39.3	17	60.7	28	100.0
	Coloured	7	50.0	7	50.0	14	100.0
	Indian	6	**100.0**	0	0.0	6	100.0
	Total	198	57.2	148	42.8	346	100.0
Highest level of education of household head	Do not know	72	50.0	72	50.0	144	100.0
	Degree	***58***	***63.7***	33	36.3	91	100.0
	Matriculation	***48***	***70.6***	20	29.4	68	100.0
	Certificate	***20***	***46.5***	23	53.5	43	100.0
	Total	198	57.2	148	42.8	346	100.0
School location	Town	***110***	***55.8***	87	44.2	197	100.0
	Township	***87***	***60.0***	58	40.0	145	100.0
	Rural village	1	25.0	3	75.0	4	100.0
	Total	198	57.2	148	42.8	346	100.0

SAS: Sciences and Applied Sciences

The data in Table 4.3 shows a breakdown of the respondents' characteristics and their responses regarding whether or not they intended to opt for the Sciences/Applied Science (SAS) stream. The majority (63.2%) of those respondents who signalled their intention to pursue the SAS stream were male. Interestingly, the number of female respondents was divided almost equally as approximately the same number of females stated that they did intend to pursue the SAS stream (51.2%) as the number who stated that they had no intention of pursuing the SAS stream (48.8%). It may indicate a strong dislike for the SAS stream.

In terms of the racial groups the Indian respondents were the keenest to pursue the SAS stream. In fact, all the Indian respondents (100%) indicated that they intended to opt for the SAS stream, compared to one half (50.0%) of the coloured respondents, and slightly more than one half (58.4%) the black African respondents. The majority of the whites (60.7%) *did not* intend to pursue the SAS stream (Table 4.3).

Another key aspect of the data in Table 4.3 is that one half (50.0%) the total number of respondents who indicated that they did not know the highest level of education of the person with whom they lived also indicated that they intended to pursue the SAS stream in Grade 10. However, it must be borne in mind that not knowing the level of education of the person with whom the respondent is living does not necessarily mean that that person has no qualifications. Nevertheless, where the level of education of the person with whom the respondent was living was known more of those respondents who lived with a person with a matriculation exemption (70.6%) or a degree (63.7%) intended to opt for the SAS stream.

Table 4.4: Bivariate analysis of respondents' school location in terms of race

School location	**Racial/Ethnic groups**									
	Black		White		Indian		Coloured		Total	
	F	%	F	%	F	%	F	%	F	%
Town	152	77.2	**26**	13.2	**6**	3.0	**13**	6.6	197	100.0
Township	142	97.9	**2**	1.4	0	0.0	1	0.7	145	100.0
Rural village	4	100.0	0	0.0	0	0.0	0	0.0	4	100.0
Total	**298**	**86.1**	**28**	**8.1**	**6**	**1.7**	**14**	**4.0**	**346**	**100.0**

Table 4.4 presents the data in respect of the respondents' race and school location. Fewer of the coloured or white respondents attended a school in a township compared to the black African respondents. In fact, the majority of the respondents, regardless of race, attended a school in a town. Black African learners only attended schools situated in each of the three school locations. This is consistent with the demographic mix of the population in the district, and in the province as a whole. It is interesting to note that, although all but two of the white respondents attended schools that were located in a town, the majority of these respondents did not opt for the SAS stream compared to the Indian or coloured respondents (cf. Table 4.3).

Performance in the Grade 8 final year Sciences/Applied Sciences related subject examinations may provide some clues in respect of the pattern of responses shown above. Performance in terms of racial categories is presented in Table 4.5.

Table 4.5: Bivariate analysis of grade 8 final year SAS examination averages for different racial groups

SAS stream Subjects		**Grade 8 final year SAS examination averages for different racial groups**									
	Intervals	Black		White		Indian		Coloured		***Total***	
		F	*%*	*F*	*%*	*F*	*%*	*F*	*%*	*F*	*%*
Natural sciences (*n=221)**	Above 50%	**115**	**79.9**	14	9.7	***5***	***3.47***	***10***	***6.9***	144	100.0
	50%	**11**	**73.3**	2	13.3	***1***	***6.7***	***1***	***6.7***	15	100.0
	Below 50%	50	80.6	***10***	***16.1***	0	0.0	2	3.2	62	100.0
	Total	176	79.6	26	11.8	6	2.7	13	5.9	221	100.0
Economics and management sciences (*n=220)***	Above 50%	122	79.7	***16***	***10.5***	***6***	***3.9***	***9***	***5.9***	153	100.0
	50%	9	75.0	***1***	***8.3***	0	0.0	***2***	***16.7***	12	100.0
	Below 50%	45	81.8	9	16.4	0	0.0	1	1.8	55	100.0
	Total	176	80.0	26	11.8	6	2.7	12	5.5	220	100.0
Technology (*n=346)*	Above 50%	***116***	***75.8***	***22***	***14.4***	***5***	***3.3***	10	6.5	153	100.0
	50%	***130***	***95.6***	3	2.2	0	0.0	3	2.2	136	100.0

Below 50%	52	91.2	3	5.3	1	1.8	1	1.8	57	100.0
Total	298	86.1	28	8.1	6	1.7	14	4.0	346	100.0

**n=221 respondents who reported their average scores* ***n=220 respondents who reported their average scores*

The data in Table 4.5 shows that, for those respondents who reported their grade 8 final year examination averages, the majority had achieved an average of 50% or above in the SAS related subjects. More of the white respondents fared better (average of 50% or above) in technology than in the natural sciences or in the economic and management sciences.

By contrast, more black African respondents fared better (average of 50% or above) in the natural sciences or in the economic and management sciences than in technology. More of the Indian and coloured respondents performed better (average of 50% or above) in the three SAS subject areas than the respondents in any of the other racial categories. Given these patterns in the performance it would be interesting to find out whether the decision to opt for the SAS curriculum stream is independent of the grade 8 final year examination in these sciences.

However, the role of gender in performance is unclear. Accordingly, the performance of the respondents in the Grade 8 final year SAS subject examinations was also analysed by gender, with the intention of whether or not to opt for the SAS stream being used as a control variable (see Table 4.6).

Table 4.6: Bivariate analysis of respondents' performance in the SAS subjects in terms of their intention to opt for the SAS curriculum stream in grade 10

Grade 8 final year SAS exam averages		**Whether will opt for SAS subject stream**											
		Yes						***No***					
	Intervals	*Male*		*Female*		*Total*		*Male*		*Female*		*Total*	
		F	*%*	*F*	*%*	*F*	*%*	*F*	*%*	*F*	*%*	*F*	*%*
Natural sciences (*n=221)**	Above 50%	**43**	**48.3**	**46**	**51.7**	**89**	**100.0**	22	40.0	**33**	**60.0**	**55**	100.0
	50%	7	77.8	2	22.2	9	100.0	3	50.0	3	50.0	6	100.0
	Below 50%	**20**	**69.0**	**9**	**31.0**	**29**	**100.0**	14	42.4	19	57.6	33	100.0
	Total	70	55.1	57	44.9	**127**	100.0	39	41.5	55	58.5	**94**	100.0
Economics													

and management sciences (*n=220)***	Above 50%	**47**	**50.0**	**47**	**50.0**	**94**	**100.0**	29	49.2	**30**	**50.8**	59	100.0
	50%	2	50.0	2	50.0	4	100.0	3	37.50	5	62.50	8	100.0
	Below 50%	**21**	**75.0**	**7**	**25.0**	**28**	**100.0**	7	25.9	20	74.1	27	100.0
	Total	70	55.6	56	44.4	**126**	100.0	39	41.5	55	58.5	**94**	100.0
Technology (*n=346)*	Above 50%	**44**	**48.4**	**47**	**51.6**	**91**	**100.0**	23	37.1	**39**	**62.9**	62	100.0
	50%	43	56.6	33	43.4	76	100.0	27	45.0	33	55.0	60	100.0
	Below 50%	**23**	**74.2**	**8**	**25.8**	31	100.0	14	53.8	12	46.2	26	100.0
	Total	110	55.6	88	44.4	**198**	100.0	64	43.2	84	56.8	**148**	100.0

SAS: Sciences and Applied Sciences; **n=221 respondents who reported their average scores **n=220 respondents who reported their average scores*

The respondents who reported their Grade 8 examination averages in the SAS related subjects are presented in Table 4.6. The data shows that, irrespective of gender, the majority of those respondents who did intend to pursue the SAS stream in Grade 10 had scored a high average (above 50%) in their Grade 8 final year SAS related subject exams.

Interestingly, more males who had stated their intention to pursue the SAS curriculum stream reported averages below 50% for each SAS subject (Natural Sciences, Economic and Management Sciences and Technology) compared to females. In fact, those females who had no intention of pursuing the SAS curriculum stream reported a better grade 8 final year examination average in each of the SAS related subjects listed above than some of the males who indicated their intention to pursue the SAS curriculum stream in grade 10. In other words, although many of the females had passed the final year Technology, Natural Sciences, and Economic and Management Sciences examinations with good grades they still indicated that they did not intend to opt for the SAS stream (see Table 4.6).

Based on the analysis of respondent demographics and school characteristics tabled above it is now necessary to assess whether the decision to opt for the SAS curriculum stream is independent of any of these factors.

4.5.2 ***Research question 2***: What demographic and/or school factors in respect of the grade 9 learners are significantly associated with their stated intentions to opt for the Science/Applied Science stream in grade 10?

All nine demographic and school characteristics of the respondents were tested for a possible association with their stated intentions to opt for the SAS curriculum stream in grade 10. Both the Chi-square and Monte Carlo tests of association were performed. It was deemed necessary to run the Monte Carlo test because, unlike the Chi-square test, the Monte Carlo test is not affected by sample size and, in most cases, is the preferred test when the sample size is small.

Of the nine demographic and school factors tested three showed significant a association with the respondents' intentions to opt for the SAS stream. However, these did not include any of the school factors. The results of these tests are presented in Table 4.7.

Table 4.7: Demographic factors showing significant association with the respondents' intentions to opt for the SAS curriculum stream in grade 10

Characteristics		Whether will opt for SAS subject stream			Pearson Chi-Square			Monte Carlo Sig. (2-sided)		
		Yes								
		F	%	Total	X^2 Value	df	Sig. (2-sided)	Sig.	Lower Bound	Upper Bound
Gender	Male	***110***	***63.2***	174	5.930	2	**0.05**	**0.029**	0.011	0.047
	Female	88	51.16	172						
Racial group	Indian	6	***100.0***	6	8.63	3	**0.035**	**0.030**	0.026	0.034
	Black	174	***58.4***	298						
	Coloured	7	50.0	14						
	White	11	39.3	28						

The data in Table 4.7 shows that both the gender and the racial group of the respondents were the two demographic factors that showed a significant association with their stated intentions to opt for the SAS curriculum stream with racial group showing the strongest association ($X^2 = 8.63$, *$p = 0.05$),* followed by gender ($X^2 = 5.93$, *$p = 0.05$)*.

A higher proportion of males (63.2%), compared to females (51.16%), indicated that they intended to opt for the SAS stream. Likewise, of the four racial groups, the Indians were the more likely to indicate that they intended to opt for the SAS stream, followed by black Africans, and then coloured – in that order. The white learners were the least likely to indicate an intention to take up the SAS stream in Grade 10.

In other words, in respect of the picture which emerged regarding intention to opt for the SAS stream the respondent is most likely to be male, Indian, and to live in a family of which the household head has either a Matriculation exemption or a degree as his/her highest qualification.

The school factor variables included: school location, gender composition of the learner population of the school, and the learner performance in the Grade 8 SAS related subjects final year examinations. The intention to opt for the SAS proved to be independent of these factors. However, a surprising element to emerge is that of performance in the SAS related subjects in the Grade 8 final year examinations as respondents indicated their intention to pursue the SAS curriculum stream without consideration of their performance in SAS related subjects in the final examinations taken the previous year.

The nature of the learner population at the respective schools did not appear to influence the responses in terms of gender. Whether in coeducational (both genders) or in single education (all male or all female) schools, the females were less likely than the males to indicate that they intended to pursue the SAS curriculum stream.

4.5.3 Research question 3: What are the attractors and/or deterrents influencing the decisions of to learners either to opt or not to opt for Science/Applied Science as a curriculum stream?

Tests were performed to assess the range of factors that either deterred or attracted the respondents in respect of their decisions to opt for the SAS stream. These attractors and deterrents are presented in separate tables below.

- *Attractors to the Sciences/Applied Sciences stream in grade 10*

The distribution of responses regarding the attractors to opt for the SAS curriculum stream in Grade 10 is presented in Table 4.7. *Intrinsic interest* pull factors proved to be the most popular reasons why respondents intend to pursue the SAS stream. These intrinsic pull factors included enjoyment of the practical work in the SAS subjects (78.3%), confidence on the part of the respondents that they would do well in the SAS stream (73.7%), and a love for the SAS subjects (66.7%).

Table 4.8: Distribution of responses regarding the attractors to opt for SAS curriculum stream in grade 10

Factors	Agree		Neutral		Disagree		Total	
	F*	**(%)**	F	**(%)**	F	**(%)**	F	**(%)**
I *enjoy* the practical work	155	**78.3**	29	14.6	14	7.1	198	100.0
I am confident that I will *do well*	146	**73.7**	37	18.7	15	7.6	198	100.0
I *love* the SAS subjects	132	**66.7**	45	22.7	21	10.6	198	100.0
My teachers show an interest in their teaching	125	**63.1**	40	20.2	33	16.7	198	100.0
Science related *jobs* are the best paying jobs	124	**62.6**	30	15.2	44	22.2	198	100.0
I always obtain *good marks* in the SAS subjects	112	**56.6**	69	34.8	17	8.6	198	100.0
The *people I know* in the SAS field do well in their careers	101	**51.0**	44	22.2	53	26.8	198	100.0
My *parents* encourage me to take the sciences	93	47.0	40	20.2	65	32.8	198	100.0
The *job market* needs people in the science field	93	47.0	40	20.2	65	32.8	198	100.0
I *want* to become a scientist	74	37.4	41	**20.7**	83	**41.9**	198	100.0
My *friends* also intend to take the SAS subjects	18	9.1	22	11.1	158	**79.8**	198	100.0
I *know people* involved in the SAS fields	18	9.1	22	11.1	158	**79.8**	198	100.0

* Frequency arranged in descending order

However, the *extrinsic interest* pull factors also proved to be important. These extrinsic interest pull factors included the interest that their teachers show in their teaching of SAS subjects (63.1%), perceptions that the SAS jobs are the best paying jobs (62.6%), and the observation that those people whom the respondents know in the SAS field do well in their careers (51.0%). Other extrinsic factors such as parental influence (47.0%), awareness of the fact that the job market needs people in the SAS field (47.0%), and role models in the community (9.1%) also influenced a few of the respondents.

Interestingly, career interest in becoming a scientist was not an attractor mentioned by many of the respondents. In fact, more respondents disagreed (41.9%) or were not sure (20.7%) that this constituted a reason behind their intentions to opt for the SAS stream than the number who did, in fact, agree. This, perhaps, represents something of a setback to the current nationwide drive to lure an increasing number of young people into the field of science in South Africa (cf. section 2.5).

Furthermore, although a higher proportion (73.7%) of respondents indicated their intention to opt for the SAS stream because they are confident that they will do well in it, in fact, approximately one half (56.6%) only of the sample always obtain good marks in the SAS subjects and had agreed to opt for the stream for this reason. In other words, it would appear that the respondents based their intention on a ‘hope to do well’ rather than on their ‘actual performance’ in the SAS related subject in the final examinations at the end of grade 8.

The majority of the respondents, regardless of racial group, indicated their intention to opt for the SAS curriculum stream because their teachers showed an interest in their teaching of the science subjects, because they enjoy the practical work, and because they are confident that they will do well in the stream (see Table 4.9). In fact, a higher proportion of Indians and blacks enjoyed the practical work and were confident that they would do well in the stream than the other racial groups. However, it is significant that a higher proportion of *Indians* and *whites/blacks* than coloureds indicated that they had teachers who showed an interest in their teaching, which, in turn, may reflect the teaching staff at their respective schools (see Table 4.9).

Table 4.9: Bivariate analysis of respondents' racial groups in respect of factors relating to intention to opt for SAS curriculum stream in grade 10

Factors		Racial group	Agree F	Agree %	Neutral F	Neutral %	Disagree F	Disagree %	Total F	Total %
1	I enjoy the practical work	Indian	5	**83.3**	0	0.0	1	16.7	6	100.0
		Black	138	**79.3**	24	13.8	12	6.9	174	100.0
		Coloured	5	**71.4**	2	28.6	0	0.0	7	100.0
		White	7	**63.6**	3	27.3	1	9.1	11	100.0
	Total		155	78.3	29	14.6	14	7.1	198	100.0
2	I am confident that I will do well	Indian	5	**83.3**	1	16.7	0	0.0	6	100.0
		Black	129	**74.1**	30	17.3	15	8.6	174	100.0
		Coloured	5	**71.4**	2	28.6	0	0.0	7	100.0
		White	7	**63.6**	4	36.4	0	0.0	11	100.0
	Total		146	73.7	37	18.7	15	7.6	198	100.0
3	I love the SAS subjects	Indian	5	**83.3**	1	16.7	0	0.0	6	100.0
		Black	121	**69.5**	34	19.5	19	10.9	174	100.0
		White	4	36.4	7	**63.6**	0	0.0	11	100.0
		Coloured	2	28.6	3	**42.9**	2	**28.6**	7	100.0
	Total		132	66.7	45	22.7	21	10.6	198	100.0
4	My teachers show an interest in their teaching	Indian	4	**66.7**	1	16.7	1	16.7	6	100.0
		White	7	**63.6**	0	0.0	4	36.4	11	100.0
		Black	110	**63.2**	38	21.8	26	14.9	174	100.0
		Coloured	4	**57.1**	1	14.3	2	28.6	7	100.0
	Total		125	63.1	40	20.2	33	16.7	198	100.0
5	Science related jobs are the best paying jobs	Black	114	**65.5**	24	13.8	36	20.7	174	100.0
		White	5	**45.5**	1	9.1	5	**45.5**	11	100.0
		Coloured	3	42.9	2	**28.6**	2	**28.6**	7	100.0
		Indian	2	33.3	3	50.0	1	16.7	6	100.0
	Total		124	62.6	30	15.2	44	22.2	198	100.0
6	I always obtain good marks in the SAS subjects	Indian	5	**83.3**	1	16.7	0	0.0	6	100.0
		Coloured	4	**57.1**	1	14.3	2	28.6	7	100.0
		Black	99	**56.9**	62	35.6	13	7.5	174	100.0
		White	4	36.4	5	**45.5**	2	**18.2**	11	100.0
	Total		112	56.6	69	34.8	17	8.6	198	100.0
7	The people I know in the SAS field do well in their careers	Black	93	**53.4**	39	22.4	42	24.2	174	100.0
		Coloured	3	42.9	1	14.2	3	**42.9**	7	100.0
		White	4	36.4	2	**18.1**	5	**45.5**	11	100.0
		Indian	1	16.7	2	**33.3**	3	**50.0**	6	100.0
Total			101	51.0	44	22.2	53	26.8	198	100.0

In addition, the majority of those respondents who indicated their intention to opt for the SAS curriculum stream because they loved the subjects were either Indian (83.3%) or black (69.5%). In contrast, the whites (63.6%) and coloureds (42.9%) were either unsure or disagreed (whites: 0.0%; & coloureds: 28.6%) that they intended to opt for the SAS stream for this intrinsic reason. (See Table 4.9 for full details). Overall, except for factors 3 and 5, a common pattern emerged in the way in which the respondents from the different racial groups responded to the factors (statements on the questionnaire): majority either agreed; disagreed; or remained neutral.

Table 4.10: Bivariate analysis of respondents' gender in terms of factors relating to intention to opt for SAS curriculum stream in grade 10

Factors			Responses							
		Gender	**Agree** *F*	*%*	**Neutral** *F*	*%*	**Disagree** *F*	*%*	**Total** *F*	*%*
1	I enjoy the practical work	*Male*	87	**79.1**	16	14.5	7	6.4	110	100.0
		female	68	**77.3**	13	14.8	7	8.0	88	100.0
	Total		155	78.3	29	14.6	14	7.1	198	100.0
2	I am confident that I will do well	Male	78	**70.9**	21	19.1	11	**10.0**	110	100.0
		female	68	**77.3**	16	18.2	4	4.5	88	100.0
	Total		146	73.7	37	18.7	15	7.6	198	100.0
3	I love the SAS subjects	Male	69	**62.7**	30	27.3	11	10.0	110	100.0
		female	63	**71.6**	15	17.0	10	11.4	88	100.0
	Total		132	66.7	45	22.7	21	10.6	198	100.0
4	My teachers show an interest in their teaching	*Male*	73	**66.4**	22	20.0	15	13.6	110	100.0
		female	52	**59.1**	18	20.5	18	20.5	88	100.0
	Total		125	63.1	40	20.2	33	16.7	198	100.0
5	Science related jobs are the best paying jobs	Male	68	**61.8**	18	16.4	24	21.8	110	100.0
		female	56	**63.6**	12	13.6	20	22.7	88	100.0
	Total		124	62.6	30	15.2	44	22.2	198	100.0
6	I always obtain good marks in the SAS subjects	*Male*	65	**59.1**	38	34.5	7	6.4	110	100.0
		female	47	**53.4**	31	35.2	10	11.4	88	100.0
	Total		112	56.6	69	34.8	17	8.6	198	100.0
7	The people I know in the SAS field do well in their careers	Male	56	**50.9**	25	22.7	29	26.4	110	100.0
		female	45	**51.1**	19	21.6	24	27.3	88	100.0
	Total		101	51.0	44	22.2	53	26.8	198	100.0
8	I want to become a scientist	*Male*	30	27.3	28	25.5	52	**47.3**	110	100.0
		Female	44	**50.0**	13	14.8	31	35.2	88	100.0
	Total		74	37.4	41	20.7	83	41.9	198	100.0
9	My *friends* also intend to take the SAS subjects	*Male*	14	**12.7**	16	14.5	80	**72.7**	110	100.0
		Female	4	4.5	6	6.8	78	**88.6**	88	100.0
	Total		18	9.1	22	11.1	158	79.8	198	100.0

Table 4.10 presents the bivariate analysis of the respondents' gender in relation to the top 7 factors relating to their intention to opt for the SAS curriculum stream in grade 10. The proportion of males to females who agreed that there was a particular factor

which influenced their intention to opt for the SAS curriculum stream was more or less the same with only occasional marginal differences in proportion. A slightly higher proportion of males than females indicated they intended opting for the SAS curriculum because they obtained good marks (male: 59.1%; female: 53.4%) in the SAS subjects, because they enjoyed the practical work (male: 79.1%; female: 77.3%), and because their teacher showed an interest in their teaching of the relevant subjects (male: 66.4%; female: 59.1%). For the males, two of their reasons were extrinsic interest (i.e. good marks and the interest shown by teachers).

However, a slightly higher proportion of females than males indicated that they would opt for the SAS curriculum stream because they felt confident they would do well in that stream (female: 77.3%; male: 70.9%), love the SAS (female: 71.6%; male: 62.7%), and because they believe that science related jobs are the best paying jobs (female: 63.6%; male: 61.8%). For these females, two of their reasons were intrinsic interest (i.e. love of the SAS subjects and the confidence that they would do well).

- *Deterrents to the Sciences/Applied Sciences curriculum stream in grade 10*

Those factors that deterred respondents from opting for the SAS stream are presented in Table 4.11. A total of 148 respondents indicated they had no intention of pursuing the SAS curriculum stream.

With the exception of a few instances, the pattern of responses in respect of each factor was divided more or less equally across the response scale, thus suggesting that the respondents were not sure whether either to disagree or agree that the particular factor has deterred them from opting for the SAS stream curriculum (see Table 4.11).

Table 4.11: Distribution of responses regarding the deterrents to opting for the SAS curriculum stream in grade 10

Factors	Agree		Neutral		Disagree		Total	
	F*	(%)	F	(%)	F	(%)	F	(%)
I find the sciences too difficult	77	***52.1***	35	23.6	36	24.3	148	100.0
I do not enjoy the SAS subjects	75	***50.7***	31	20.9	42	28.4	148	100.0
I always receive low marks (i.e. do not pass SAS subjects)	64	***43.2***	33	22.3	51	**34.5**	148	100.0
I do not understand the SAS subjects	58	39.2	44	29.7	46	**31.1**	148	100.0
I do not see how SAS subjects apply in real life	55	37.2	40	27.0	53	**35.8**	148	100.0
I have no science role models in my community/village	50	33.8	29	19.6	69	**46.6**	148	100.0
It takes a long time to read and study SAS subjects	47	31.8	32	21.6	69	**46.6**	148	100.0
Terminology used in SAS is not used in everyday life	45	30.4	44	29.7	59	**39.9**	148	100.0
My teacher in the SAS class is unfriendly	24	16.3	19	12.8	105	**70.9**	148	100.0
Too much competition among the boys in the class	22	14.8	34	23.0	92	**62.2**	148	100.0
My parents do not want me to take SAS subjects	20	13.5	13	8.8	115	**77.7**	148	100.0
My teacher does not allow me to take part in the practical work	16	10.8	22	14.9	110	**74.3**	148	100.0

The data in Table 4.11 indicates that those factors that deterred the majority of the respondents included the fact that they find the ***sciences too difficult*** (52.1%) and that they ***do not enjoy*** the SAS subjects (50.7%). Nevertheless, less than one-third disagreed with these two factors. Likewise, although 43.2% of the respondents agreed that either ***frequent failure or low*** marks in the SAS related subjects deterred them from pursuing the SAS curriculum stream, just over a third (34.5%) disagreed with this reason. All three of these factors are located within the individual internal locus of control.

Factors outside of the locus of control of the individual appeared to have relatively little to do with the respondents' intentions not to pursue the SAS curriculum stream. *Teacher discouragement* was low – affected only a few. More than 60% of the respondents disagreed that their intention not to opt for the SAS stream was as a result of the 'unfriendly nature' of their teacher (70.9%), or because the teacher had not allowed them to take part in practical work (74.3%). Furthermore, *parental discouragement* appeared to act as a deterrent for only a few of the respondents. Compared to the 13.5% who agreed the majority (77.7%) disagreed that their intention to pursue a non-science stream was as a result of discouragement on the part of their parents. *Competition* among learners in the classroom situation was also low – affected less than 15% of the respondents.

It emerged that the most significant deterrent was a lack of understanding of the SAS subjects, which is, perhaps, an umbrella factor for the other factors.

Table 4.12 Bivariate analysis of respondents' gender in terms of the top four factors relating to deterrents to opting for the SAS curriculum stream in grade 10

Factors		Gender	Agree		Neutral		Disagree		Total	
			F	*%*	*F*	*%*	*F*	*%*	*F*	*%*
1	I find the sciences too difficult	*Male*	29	45.3	17	26.6	18	28.1	64	100.0
		female	48	***57.1***	18	21.4	18	21.4	84	100.0
	Total		77	52.0	35	23.6	36	24.3	148	100.0
2	I do not enjoy the SAS subjects	Male	30	46.9	12	18.8	22	34.4	64	100.0
		female	45	***53.6***	19	22.6	20	23.8	84	100.0
	Total		75	50.7	31	20.9	42	28.4	148	100.0
3	I always receive low marks (i.e. do not pass the SAS subjects)	Male	23	35.9	14	21.9	27	42.2	64	100.0
		female	41	***48.8***	19	22.6	24	28.6	84	100.0
	Total		64	43.2	33	22.3	51	34.5	148	100.0
4	I have no science role models in my community/village	*Male*	33	**51.6**	7	10.9	24	37.5	64	100.0
		Female	17	20.2	22	26.2	45	**53.6**	84	100.0
Total			50	33.8	29	19.6	69	46.6	148	100.0

Table 4.12 presents a bivariate analysis the respondents' gender in terms of the top four factors relating to deterrent to opting for the SAS curriculum stream in grade 10. It emerged that the females respondents were the most affected by these specific factors as a higher proportion of females than males reported that they did not intend to pursue the SAS stream either because they receive low marks in the SAS subjects, do not enjoy the SAS subjects, and, generally, find the sciences difficult.

4.5.4 ***Research question 4***: Is there a significant difference between male and female learners in respect of the attractors/deterrents influencing their decisions either to opt, or not opt, for the Science/Applied Science curriculum stream?

ANOVA tests were conducted to explore the difference by gender in respect of those factors that attract the respondents to opt for the SAS stream. All 12 factors were analysed for differences. Of these 12 factors, only two factors differed significantly. The results are presented in Table 4.13.

- *Attractors to SAS stream*

Table 4.13: Mean and ANOVA tests for factors showing a significant difference between both gender and attractors to opting for the SAS curriculum stream

Factors	Gender	N	Mean	df	F	Sig.
I *want* to become a scientist	Male	110	2.80			
	Female	88	**3.15**	1	7.689	0.006
Total		198	2.95			
Because my *friends* also intend to pursue the SAS curriculum stream	Male	110	**2.40**			
	Female	88	2.16	1	7.498	0.007
Total		198	2.29			

The data in Table 4.13 illustrates that the male and female respondents differed in terms of both the influence exercised by their friends' intentions to pursue the SAS curriculum stream and their personal desires to become scientists on their own intentions to opt for the SAS stream. In terms of the factor "I want to become a scientist" the female respondents (mean = 3.15) presented a higher mean value than the male respondents (mean = 2.80). In other words, more females agreed in respect of this factor than males (cf. Table 4.10). The significance of the F-value ($F = 7.689$; $p < 0.01$) suggests that the female respondents were more likely than the male respondents to agree that they intended to opt for the SAS stream because they wanted to become scientists.

By contrast, Table 4.13 illustrates that the male respondents (mean = 2.40) presented a higher mean value than the female respondents (mean = 2.16) in respect of the factor: "Because my friends also intend to pursue the SAS curriculum stream". In other words, more males agreed in respect of this factor than females (cf. Table 4.10). The significance of the F-value (*F = 7.498;* $p < 0.01$) suggests that the male were respondents more likely than the female respondents to agree that they intended to opt for the SAS stream because their friends also intended to pursue the same stream. In other words, the female respondents were more likely to disagree with this factor.

In respect of the other factors (cf. Table 4.8) there did not appear to be any significant difference between the respondents which is, perhaps, somewhat surprising given the literature evidence to the contrary (cf. section 4.6.4).

- *Deterrents to the SAS curriculum stream*

Of the 12 factors that measured the deterrents to opting for the SAS curriculum stream (cf. Table 4.11) there was a significant difference in terms of the gender of the respondents in respect of one factor only – see Table 4.14

Table 4.14: Mean and ANOVA test for factors showing a significant difference between both gender and attractors to opting for the SAS curriculum stream

Factors	Gender	N	Mean	df	F	Sig.
No science role models in my community/village	Male	64	**3.14**	1	10.990	0.001
	Female	84	2.67			
Total		148	2.87			

Male and female respondents differed in respect of the influence of the 'absence of a science role model in my community/village' on their own intention *not* to pursue the SAS curriculum stream in grade 10. The male respondents (mean = 3.14) presented a higher mean value than the female respondents (mean = 2.67) for this factor. In other words, more males respondents agreed to this factor than females respondents (cf.

Table 4.12). The significance of the F-value (*$F = 10.990$; $p < 0.01$*) suggests that the male respondents were more likely to agree that the absence of a science role model in their community/village deterred them from opting for the SAS stream compared to the female respondents.

4.6 DISCUSSION

This quantitative phase of the study explored those factors that, in the opinion of grade 9 learners, play a role in influencing their intentions to select the Sciences/Applied Science (SAS) curriculum as a stream for Grade 10. Central to this discussion was an attempt to determine whether, and how, these attractor/deterrent factors which were highlighted by the learners, differ in respect of certain demographics and school characteristics.

4.6.1 Learners' demographic characteristics and issues in respect of their intentions to opt for the SAS curriculum stream

The study found that the majority of the respondents in the sample did intend to pursue the SAS curriculum stream in grade 10. The evidence also indicates that both male and female learners, and learners from all four racial/ethnic categories represented in the sample, did intend to opt for the SAS curriculum stream. Nevertheless, the proportion of learners within each of these demographic categories was not the same. While both male and female learners had indicated their intention to pursue the SAS curriculum stream, it emerged that more males than females had expressed this intention. In fact, the intention to pursue the SAS curriculum stream in grade 10 proved to be dependent on gender. Even in instances in which the school attended was either an all girls' or all boys' school (i.e. single-gender), more males than females indicated a preference for the SAS curriculum stream.

The finding that the males respondents were more interested than the female respondents in pursuing the SAS curriculum stream is not particularly new nor is it unsurprising. In fact, it merely confirms the evidence reported in previous research which showed that gender has always been a mediating variable in terms of the cohort of those who pursue the SAS curriculum stream in schools (Cavanagh, 2009). Reviewers of the countless studies conducted since the 1970s Cavanagh (2009), Hacker (1992) and Fennema (1977) have arrived at the conclusion that, in general, the relative participation rates of boys and girls in programmes of science, technology and vocational education are higher among boys than girls. However, the question arises as to *why, when these subjects are not compulsory, do males and females often exercise markedly different choices, even, as this study has indicated, in those contexts in which a single gender learner population prevails*? In other words, is there something about the nature of the SAS subjects that, intrinsically, renders these subjects unattractive to girls as subjects to study?

Various explanations for this phenomenon have been advanced, and it would seem that the following, inter alia, all play a role – cultural issues, socialisation, teachers' responses, and sets of issues clustered around the science and technology curricula and the associated procedures for assessing the progress and understanding of learners (*cf. chapter 2, section 2.4*). For instance, certain researchers (Jenkins, 1997) have argued that (SAS) science and technology are essentially masculine - and Western - in their ontology – an argument that seems to offer a convenient explanation of the reason why an education in these subjects often appears to be an alienating experience for many females. Nevertheless, it could be argued that this masculine perception, where it exists, is an outcome of uncontested processes of socialisation and stereotyping in the wider society. This notion clearly needs to be challenged if there is to be any progress in the bringing of parity in gender selection.

Furthermore, at the level of the curriculum itself, Jenkins (1997:12) contends that any curriculum necessarily selects, and, thereby, privileges certain kinds of activities and forms of knowledge and sends both implicit and explicit messages about these activities and knowledge to learners and teachers alike. This argument would suggest that, in terms of the SAS curriculum, certain messages are communicated which may dissuade females from selecting the SAS curriculum stream. Bernstein (1990:69) speaks of a message system within curriculum which is capable of transmitting the kind of gender-based messages to which Jenkins refers. Of significance here then is the fact that the curriculum itself may account for part of the explanation for the male preference for the SAS curriculum stream in schools.

The response of the teachers is also important in this respect because it is the teachers who convey the curriculum (Bernstein, 2006:1). In transforming the prescribed curriculum into the delivered curriculum and engaging in the dynamics of classroom interaction teachers necessarily draw upon their understanding of their subject and their beliefs about how best to teach and to promote learning (Jenkins, 1997). Teachers also draw upon a set of wider cultural assumptions, not least about the role expected of boys and girls within society. There is evidence to suggest that these assumptions shape the way in which teachers treat boys and girls in science, mathematics, and technology classes (Cavanagh, 2009:5).

It would appear that academic performance in the SAS subjects does not play a significant role in learner choices (see Table 4.6). Females with above average results in the Grade 8 final examinations in natural science and technology appeared not to want to purse the SAS stream, while, on the other hand, males with below average results in these Grade 8 final examinations in natural science and technology indicated a wish to pursue the SAS curriculum stream. In South Africa, generally, when it comes to gender differences in terms of performance, girls and boys performed almost equally in the 1999 and 2003 TIMSS (Trends in International Mathematics and Science Study) test (Van der Linde, 2004). The 1999 TIMSS scores revealed that, whereas there was no gender difference in terms of national performance, there was a difference in the performance of the girls and boys in African schools. In TIMSS 2003 there was no gender difference in terms of any of the groups. The above would seem to suggest that equalising gender in the SAS curriculum stream may require the overcoming of perhaps deeply entrenched cultural, socialisation, curricula, teaching, and attitudinal challenges.

Furthermore, the evidence in this study indicates that the intention to pursue the SAS curriculum stream in grade 10 was dependent of respondents' ethnic groups (cf. Table 4.7). While black, white, Indian, and coloured learners all indicated an intention to opt for the SAS curriculum stream it did emerge that the Indian learners were the more likely to opt for the SAS stream, followed by black learners. White learners were the least likely to opt for this stream. There is no single, straightforward explanation in the literature for the pattern of choice revealed by the ethnic groups in terms of their decisions to opt for the SAS curriculum stream. One strand of evidence has linked this pattern of choice to social stigmatisation and stereotypes (Steele, 1997; Steele & Aronson, 1995). However, another strand of literature has linked it to peer, achievement and rational decision making based on the learners' judgment of their capabilities in respect of advanced studies (Van der Linde, 2004:2).

In the international literature, for instance, in the United States of America, evidence indicates that prior achievement (capability) and peer choices exercise a significant influence on course taking at secondary school level. However, in this study, peer choice was not a significant factor for individuals in the different ethnic groups, though the Indian respondents had performed consistently better than other ethnic groups in the Grade 8 final examinations in natural science and technology (see Table 4.5). Nevertheless, as the TIMSS study has consistently revealed (Van der Linde, 2004:1), it must be noted that Asians (Indians) are known for their outstanding performance in the sciences and in mathematics. Thus, their keener interest in the SAS curriculum stream may be linked to issues of competence.

Literature from the United States of America indicates that, although some researchers have found that minority and low socio-economic status (SES) learners are more likely to be assigned to lower curriculum streams at secondary school level, even after ability has been held constant (Oakes, 1985), other researchers have found that the expectations and guidance of others (parents, teachers, guidance counsellors, and peers) are influenced by both race and SES and that these latter mediating variables influence stream selection or placement (NSF, 2002). In other words, the pattern in the interest shown by the ethnic groups to pursue the SAS curriculum stream may be an outcome of the expectations and guidance of significant others, both within and outside of the school context. Petersen, Kraus and Windham (2005) make the point that both the home and school environments of learners have a strong influence on their academic performance, regardless of race and ethnicity. This view could, perhaps, be extended to include even those decisions of learners in respect of curriculum stream, which may then constitute a factor in terms of the racial/ethnic group responses in this study.

The low interest in pursuing the SAS stream evinced by the white learners was surprising. In addition, the majority of these white learners also attended schools which were located in the town/city areas. There is a perception in South Africa that suggests there is a racial hierarchy of ability in respect of mathematics and sciences, in terms of which learners identified as *Asian* [Indian] and *white* are placed at the top, and those learners identified as Coloured and African are assigned to the bottom (in that sequence). This worldview may be deduced from the arguments of Van der Linde (Van der Linde, 2004) and others (Wilcox, 2004).

Such worldviews may have negative impacts. Studies have shown that such framings often become internalised by teachers and school officials, thus leading both to deficit-oriented beliefs about black learners and pernicious ways of sorting and stratifying these learners in terms of educational opportunities (e.g. Lewis, 2003; Sleeter, 1993). Research by Steele (1997) and Steele and Aronson (1995) on *stereotype threat* – the threat of being perceived as fitting a negative stereotype or the fear of poor performance confirming that stereotype – has clearly shown that discursive practices and policies that frame certain learners as underachievers, and at-risk, often have a negative effect on academic performance should this discourse become part of the social context in which learners are attempting to learn. Although an individual's intention to take a particular course is not necessarily based solely on competence (as the above discussion indicates), the issue of competence does clearly play a role. Thus, the evidence in this study, perhaps, also points to a need to dispute those worldviews that place blacks at the bottom of the racial hierarchy of sciences and mathematics ability, not only because of its potential negative impact, but because it may not be a valid worldview.

There is, thus, clear evidence of significant differences in terms of the intentions expressed by the racial groups to opt for the SAS curriculum stream. The reasons for these differences are neither simple nor straightforward, but, indeed, complex, and include learner competence in the SAS subjects, as well as the expectations and guidance of significant others both within and outside of the school context in terms of which potentially demotivating notions of racial hierarchy in respect of science and mathematics ability appear to prevail.

4.6.2 Learners' school characteristics and issues in respect of their intentions to opt for the SAS curriculum

Another key finding in this study is that the intention to pursue the SAS curriculum stream was expressed by learners whether they attended schools in towns, townships, or rural villages. However, despite the fact that the majority of the study sample came from schools located in urban town/city areas, the majority of those learners who stated their intention to select the SAS curriculum stream attended schools located in townships (see Table 4.3). In other words, fewer of the learners from schools located in urban town/city areas expressed the intention to opt for the SAS curriculum stream in grade 10 than those learners who attended schools located in townships. This phenomenon may be related to parental influence in terms of which learners in township schools come from families who want their children to pursue the SAS curriculum stream in school as a means of, not only preparation to finding good jobs in the cities, but also as a way of positioning oneself for future careers in order to escape life in the townships. Social reference groups do influence education choices. Park and Lessig (1977) speak about normative referents in terms of which family and other non-family groups instil in an individual norms, attitudes, and values through direct interaction which, in turn, allows for a significance degree of interaction that impacts on the choices of the individual.

Nevertheless, despite the above observation, there was no significant association found in this study between school location (or any of the other school characteristics) and learner intention to opt for the SAS curriculum stream. Thus, the intentions expressed by learners were independent of both the location of their school, and other school characteristics such as learner performance in the grade 8 final examinations in the Natural Sciences and in technology related subjects. Nevertheless, this evidence is surprising in view of the fact that previous research has suggested that a differential in the facilities for SAS subjects in schools – often encountered in conditions in rural and urban schools – may impact on learners' interest in certain course, with learners in schools with few or no SAS facilities being less interested in pursuing the SAS curriculum stream than learners in highly resourced schools (Bernstein, 2006:2; Van der Linde, 2004:1).

4.6.3 Issues related to the attractors and deterrents in respect of opting for the SAS curriculum stream

4.6.3.1 Intrinsic and extrinsic attractors

One of the key findings that emerged in the study is the fact that both intrinsic and extrinsic related factors influenced the grade 9 learners' intentions to opt for the SAS curriculum stream in grade 10 with the intrinsic factors having the greatest influence on the majority of the learners. Many of these factors included an enjoyment of the practical work in the SAS subjects, confidence that they would do well in this stream, and a love of the SAS subjects. Deci (2000:10) asserts that intrinsic value is the value that an object has "in itself" or "for its own sake", or "as such", or "in its own right", as an intrinsic property. Intrinsic valuing forms the basis of intrinsic motivation, which, in turn, is seen by educational theorists as essential to learning (Schunk, 2004:320).

A number of local and international studies report evidence of intrinsic motivation underlying learner behaviour in terms of pursuing specific school courses. Amos and Boohan (2002) found that learners tend to study science and applied science in order to satisfy their curiosity about the world around them, to engage in direct experience, to understand the way in which science contributes to technological change, and to be in a position to question and to discuss science-based issues. Sears (2000) is in agreement when arguing that some children study science in order to become better operants within their environments. All of these perspectives reflect images of intrinsic forces triggering an interest in the sciences and in applied science. Although the set of factors mentioned by the grade 9 learners in this study differ from those highlighted by

Amos and Boohan, nevertheless, the factors mentioned in this are similar in nature to those highlighted by Amos and Boohan in that they are all intrinsic in nature.

The most powerful attractor of learners in terms of wanting to pursue the SAS curriculum stream was an enjoyment of the practical work and, in respect of this factor, it is evident that one source of the learners' intrinsic motivation lies within the curriculum. The identification of this intrinsic factor is significant for both teachers and school officials as it means that they will be able to make use of this element in strategies designed to stimulate the interest of a greater number of learners in taking SAS related subjects at school level. It also provides teachers with some degree of leverage to adapt teaching strategies that will serve to motivate learners. Hirsch (2001) is of the view that one way in which to encourage interest in a curriculum is through the promotion of learner autonomy. Self-determination theorists, such as Ryan and Deci (2000), suggest that building teaching strategies around particular interests which have been identified by the learners themselves is an important way in which to foster autonomy among learners. Self-efficacy and the promotion of autonomy are central aspects of intrinsic motivation (Ryan & Deci, 2000).

It often happens that when the intrinsic motivation of learners is discussed the sources of this motivation are not identified. As a result, education practitioners are forced to speculate what needs to be to be done in order to enhance and to sustain this type of motivation. Of significant value to the evidence of this study is the fact that the study draws particular attention to the sources of learner intrinsic motivation, thus enabling teachers to utilise this information. In addition, Deci (2000:12) suggests that choice, acknowledgement of feelings, and opportunities for self-direction all enhance intrinsic motivation. This information, in turn, may be incorporated into SAS curriculum stream teaching in order to boost its intrinsic value to the learners. It is essential that teachers be aware that intrinsic motivation may be subdued or diminished if it is not elicited and sustained (Ryan et al, 1997).

Nevertheless, while intrinsic factors did constitute powerful attractors, there were also extrinsic interest related factors which also prompted learners to select the SAS curriculum stream. These extrinsic factors were a composite of job opportunities in the fields of science and technology, teacher interest in their teaching of SAS subjects, parental influence, and science/technology role models. This evidence clearly places teachers and parents in a position of influence in respect of learners' choices of their courses. There is a wealth of previous research pointing to the importance of both teachers and parents in this process (*cf. chapter 2, section 2.4.2*). However, unlike the evidence of this study, certain findings in this previous research place teachers and parents in a negative light regarding learners' stream decisions. For instance, Bhana (2005) speaks about teachers perpetuating gender ideologies in the classroom situation. The fact that teachers may be viewed as an extrinsic resource stimulating the interest of learners in following the SAS curriculum stream in schools is a significant development.

Certain of the extrinsic related factors were linked to a career interest in becoming a scientist, while good marks in the SAS subjects were a key factor for many of the respondents. Nevertheless, there were only a few learners who focused on these two extrinsic related factors. Extrinsic factors are instrumental. Research illustrates that extrinsic motivation reflects those factors which are treated as a means to some other end or purpose (Schunk, 2004). Although extrinsic factors have been identified, motivation theorists argue that, in view of the long term benefits of intrinsic interest, it would be helpful to assist learners gradually to shift their motivation in respect of specific school curricula from extrinsic to intrinsic interest factors (Ryan & Deci, 2000). These dynamics are important factors to be taken into account in the efforts to develop strategies to promote the SAS curriculum stream to learners.

There is a sustained effort being made in South Africa to promote a greater interest and participation in the SAS curriculum stream in schools (cf. chapter 2, section 2.4). The extrinsic focus on job opportunities may be an outcome of these strategies because bursaries are being made available to learners to pursue science and technology at tertiary level. In general, though, the fact that learners focus on extrinsic factors in terms of their intentions to pursue the SAS curriculum stream is unsurprising as extrinsic factors have always been a powerful motivator among learners their pursuing of specific curricula (Schunk, 2004). School officials may benefit from these extrinsic factors by packaging them into strategies to encourage more learners to show an interest in following the SAS curriculum stream.

Nevertheless, it must be noted that a strict separation of the attractors to the SAS curriculum stream into an intrinsic-extrinsic dichotomy is not, in reality, a clear-cut issue. It is possible for learners to be attracted by both intrinsic and extrinsic factors, and not one or the other. Extrinsic valuing is often a means to intrinsic value formation (Deci & Ryan, 2000). It is possible that an enjoyment of SAS practical work has intrinsic value, while, in the other hand, the interest that the teachers show in their teaching of SAS subjects may not have intrinsic value, yet still be instrumental as it generates happiness. The point to remember is that any strategy to encourage greater participation in the SAS curriculum stream must take both sets of factors into consideration.

4.6.3.2 Internal and external loci of control deterrents

The evidence in the study reveals that factors linked to learners' views of their competency in terms of doing well in the SAS curriculum stream (internal locus of control), as well as factors such as teacher discouragement and competition within the class context (outside of their locus of control), may dissuade learners from pursuing the SAS curriculum stream. However, the most significant deterrent proved to be learners' competency – lack of understanding of the SAS related subjects, frequent failure or low marks in the SAS related subjects, and the experience of the sciences as too difficulty and too unpleasant. These all indicate a strong attribution by learners to factors within themselves in respect of their lack of interest in the SAS curriculum stream, and a sense that they are able to act purposefully to change their circumstances.

The fact that the learners linked their intention to avoid the SAS stream to weaknesses in their own competence is one of the findings of this study which corresponds with findings in studies conducted by attribution researchers. Most attribution studies within education postulate four casual factors of attribution: ability, effort, task difficulty, and luck (Schunk, 2004). Whitley and Frieze (in Smith, 1994:201) suggest that learners view the expenditure of effort as a fundamental expectation of the school environment. They even go on to suggest that this expectation may be so powerful that learners are predisposed to make attributions of effort, regardless of the outcome (Whitley & Frieze in Smith, 2004:201). In terms of the learners in this study their emphasis on their own lack of ability to understand SAS concepts suggests that they attributed their decisions not to pursue the SAS curriculum stream to low ability and to task difficulties, rather than to issues of effort.

In forming attributions people make use of situational clues. Previous research indicates that social norm factors such as either failing or passing a test, or else task features such as the relative ease with which one is able to do a task play a role in one's executing a task (Schunk, 2004; Weiner, 1992). It may have been the frequent failures that the learners had experienced in SAS related subjects that led them to draw conclusions, not only about the task difficulty, but also about not opting for the SAS curriculum stream. Research suggests that the task of convincing a learner, who has attributed his/her decision not to take the SAS stream to issues related to task difficulty and/or low ability, to change this decision is far more complex than trying to convince a learner who has attributed the decision not to take the SAS curriculum stream to low effort (Chapin & Dyck, 1976). The research of Chapin and Dyck (1976) has shown that teaching learners to attribute failures to low effort, for instance, enhances effort attributions, expectancies, and achievement behaviours. In other words, learners would be more interested in opting for Science and Applied Science, and trying harder in order to succeed. This evidence suggests that convincing learners to reverse their decisions may not be as easy as it may seem, but that it requires strategies that take attribution issues into account.

4.6.4 Gender differences in issues related to the attractors and deterrents to opt for the SAS curriculum stream

4.6.4.1 Gender and the attractors to the Science and Applied Science curriculum stream

A key finding that emerged from this study is that male and female learners differed significantly in terms of two of the twelve factors that attracted the respondents to opting for the SAS curriculum stream. More females than males intended to opt for the SAS curriculum stream on the basis of the extrinsic factor of 'wanting to become a scientist'. On the other hand, more males than females expressed their intention of opting for the SAS curriculum stream on the basis of the extrinsic factor of 'their friends plan to pursue the SAS stream'. In order words, peer influence was a more important factor for the male respondents whereas career was a more important factor for females. However, it is important to note that the factors that influenced their intentions were, in both instances, extrinsic factors. This focus on different extrinsic factors may be a function of gender differences in terms of the values that influence the decision making process of learners. One such value involves collective consensus in terms of which male learners tend to be more influenced by the collective decision of their peers as regards school work than females who tend to make subject decisions more independently.

Another explanation for this focus on extrinsic factors – despite the difference in these extrinsic factors – may have something to do with a quest among males for social acceptability and peer fidelity on the one hand, and the recent drive nationwide in South Africa to encourage greater female participation in the science related curriculum stream at school level, and the pursuit of careers in the fields of science and applied science. In terms of the latter a central aspect of the recent effort to promote female participation in the Science and Applied Science curriculum stream lies in the fact that females appeared to have shifted their focus away from the traditionally “feminine” accepted courses, which, it is claimed, do not cater for the demands of modern technology, and, thus, fail to generate employment opportunities for girls (UNESCO, 1999).

The interest among females in pursuing the Science and Applied Science curriculum for career related reasons signal a break away from the past. An UNESCO study (UNESCO, 1999:1) reveals that historically, females generally account for significantly higher percentages of enrolments in courses of study oriented to commercial and service occupations rather than in courses related to occupations in the fields of industry and engineering. Nevertheless, it is the core academic subjects that determine access to higher education, and secondary education plays an important role in success in higher education. The factors that separate the male and female learners’ interest in and intention to pursue the Science and Applied Science curriculum stream is a key finding of this study. This evidence may be used in the devising of strategies to encourage greater interest among female learners in the Science and Applied Science curriculum stream at school level.

Contrary to expectations the gender composition of the learner population at the schools in this study appeared to have no significant influence on the intention of the male and female learners to select the Science and Applied Science curriculum stream. This is in contrary to the findings of a study conducted by Pascarella and Terenzini (1991) who reported, for instance, that attending a single-sex school enhances the orientation of the female learners to sex-atypical career choices.

Nevertheless, the evidence in this study shows that school characteristics such as whether the school attended was either single-sex or co-educational, had no significant influence on the choices of the male and female learners in respect of the curricula stream they intended to pursue. A report from UNESCO (UNESCO, 1999:3) on the participation of girls in scientific, technical and vocational education in Africa suggests that, when the above phenomenon is explained, the social system in which schools operate may constitute one of the causes. In other words, the "masculine" image associated with science is one of the main reasons for the "non-orientation" of females in terms of the Science and Applied science curriculum, even in a single-sex environment.

A major finding which emerged from this study is the non-significance of influences such as the way in which the Sciences and Applied Sciences are taught, on the intention of male and female learners to select the Science and Applied Science curriculum stream. Past research has shown that the way in which Science and Applied Science is presented may serve as a "put off" for girls (UNESCO, 1999: 1-5); Sax & Bryant, 2006:52-53). In other words, this literature is suggesting that the "chilly climate" (Sax & Bryant, 2006:53) or else the notion that the educational experiences of females which are marred by subtle, and sometimes not so subtle, gender biases both inside and outside of the classroom, may result in gender differences in terms of the choices that learners make regarding their pursuing of the Science and Applied Science curriculum stream. However, the majority of the learners, both male and female, in this study did not relate any experiences to suggest that the Science and Applied Science teaching to which they had been exposed had put them off from wanting to pursue the Science and Applied Science curriculum stream. In fact, for many, their enjoyment of the practical work was their main reason for intending to pursue this curriculum stream. Both gender groups were of the opinion that their teachers were interested in the subject they were teaching. In this sense, it may be argued that the effort to present the Science and Applied Science curriculum stream from a “practical perspective” may partly account for the lack of significant differences between the gender groups, since, as Astin (1993:406) asserts, exposure to both an uniform curriculum and an uniform environment may reduce or weaken the stereotypic differences between men and women in terms of behaviour, aspirations and achievement.

At the same time, the notion found in the literature that females are, to a large extent, less capable of learning Science and Applied Science (UNESCO, 1999; Sax & Bryant, 2006) and that this phenomenon may explain gender differences in school subjects choices, did not materialise in this study. There was no significant differences found in the academic performance (in terms of subject marks/grades) of the genders nor did academic performance cause the male and female respondents to differ significantly in their intention to select the Science and Applied Science curriculum stream. In some instances, despite the fact that the female respondents had performed better than the males in their grade 8 final examinations in science related subjects, the females respondents still indicated that they did not intend to pursue the Science and Applied Science curriculum stream in grade 10. The no difference in achievement appears to be a result of the general confidence and ambition on the part of the females and their belief that, academically, they are capable of performing as well as the males in the Science and Applied Science curriculum stream.

4.6.4.2 Gender and deterrents to the Science and Applied Science curriculum stream.

In terms of those factors that dissuaded both male and female learners from pursuing the Science and Applied Science curriculum stream, one factor only of the twelve measured was significant in terms of gender – males, rather than females, were deterred from the SAS stream as a result of the absence of “science role models” in their communities. This evidence is fairly surprising because the literature, generally, suggests that it is females who are the more likely to be deterred from the sciences as a result of a lack of role models (UNESCO, 1999; Sax & Bryant, 2006). It may be that the nationwide drive in South Africa to promote the greater participation of females in the Science and Applied Science field has exposed females to more visible role models but that, in terms of males, there has been less emphasis on male role models in the field. A recent study by UNESCO (1999) found that role models, both within and outside of school, are a crucial factor in encouraging the involvement of girls (and boys) in science. This evidence underscores the importance of emphasising role models for both genders.

4.7 SUMMARY

This chapter contains the findings of the quantitative phase. The demographic and school characteristics of those Grade 9 learners who intend to opt for the Science and Applied Science curriculum stream were addressed. The association between demographic and school factors, attractions or deterrents for learners in terms of their decisions whether or not to opt for the Science and Applied Science curriculum stream and whether there is a significant gender difference in respect of these attractions or deterrents were discussed. It was found that the demographics of the schools were not significant in the learners' choice of subjects. Both extrinsic and intrinsic motives played a role in the attraction of learners to the Science and Applied Science curriculum stream. There was no significant gender differences in the choices made and, at times, the female respondents proved to have performed better their male counterparts in the Grade 8 final examinations in the Science-related subjects.

The next chapter contains an analysis and discussion of the interview data – a follow up to the quantitative phase.

CHAPTER 5

FINDINGS AND DISCUSSION OF THE FOLLOW-UP QUALITATIVE CASE STUDY

5.1 INTRODUCTION

This chapter presents the data which emerged from the follow-up qualitative phase. This phase was conducted among the teachers of the Grade 9 learners. The aim of this follow up phase was to ascertain the teachers' reactions in respect of some of the key issues that the learners had raised during the quantitative phase about factors which played a role in their intentions either to select or to avoid the SAS curriculum stream. After an explanation about the realisation of the sample, the chapter outlines the key findings that emerged from this phase of the study. Central to this chapter is a discussion of evidence from both the quantitative and qualitative phases. This allows for both an in-depth and holistic reflection on the key findings and a comparison with those findings which emerged from the literature review. The chapter ends with the summary of the contents.

5.2 RESEARCH FINDINGS

5.2.1 Realisation of the sample

The sample for this qualitative phase was drawn conveniently. Three Grade 9 teachers participated. One of the teachers was selected from a school in a township, one from a former model C school (all girls' school) in the town, and one from a former model C school (all boy's school), also in a town. The teachers were selected from the same schools as the learners that participated in the study.

5.2.2 Findings

5.2.2.1 Reactions to practical work in SAS lessons

Responses were elicited from the teachers regarding the evidence that the majority of the Grade 9 learners who intend to opt for the SAS curriculum stream had agreed that their enjoyment of practical work was one of the key reasons behind their wanting to pursue this stream. The teachers acknowledged engaging in practical work with their learners. However, it emerged that this practical work took on different forms as is indicated by the following two comments:

> Yes, we do practical work but it's mainly through demonstration… learners watch, and ask questions during or/and after the exercise… I think they find that exciting. But we have problems with apparatus – they are just not enough [T1].
>
> They [learners] get a practical report sheet to read on when they come in. They are given 10 minutes to read. If the practical is safe enough they get a chance to do it on their own. Apparatus is set up before they come in. After they have read the practical they know how to carry on with the method, and they do the experiment. They obtain the results and they draw up conclusions. If it is a major practical, they have to formulate their own hypothesis. They are given apparatus, they write investigation questions, also design, and their own experiment. Then they formulate their findings [T2].

These comments provide a sense of how the practical work is undertaken. Demonstrations and worksheets were common strategies in the practical work of T1, while T2 reported carrying out experiments. From the evidence in the literature there is nothing new in these approaches as they are common ways of teaching sciences (DoE, 2002). It would appear that both the teaching of SAS subjects and learning conditions at each of the school where the two teachers work impact on the way in which they engage in practical work. This observation is unsurprising as various studies have reported on marked disparities in both the teaching and other conditions in South African schools (DoE, 2006; HRW, 2004).

In all three schools the teachers were unsurprised by the motivation to opt for the SAS curriculum stream as a result of the practical work undertaken by the learners. This is because practical work informs the teaching strategy of the teachers. The practical work involves group work. The literature review in chapter 2 reveals the significance of practical work in stimulating interest in SAS subjects. According to Hayward (2003) all sciences have an essentially practical basis. In the learning outcomes in physical science learning outcome one stresses skills development as learning outcome one is about practical science inquiry and problem-solving skills (DoE, 2003:13). Hayward (2003) argues that practical work helps learners to gain an understanding of both facts and concepts and it encourages active learning. Practical work instils in the learners the confidence to work independently rather than always rely on the teacher for assistance. This may be the reason why the learners indicated that they intended to select the Science and Applied Science curriculum stream because they enjoyed the practical work conducted in their classes.

5.2.2.2 Reactions to learners' lack of interest in the SAS curriculum stream

The teachers reacted negatively to the information that a sizeable proportion of the learners had no intention of opting for the SAS curriculum stream. This lack of interest on the part of learners was attributed to systemic factors, curricula, and factors related to the learners themselves. The teachers explained:

> If we had enough resources, like apparatus, they could understand science better. We need more apparatus to engage learners in experiments [T1].
>
> I see that some learners discover in grade 9 that Maths and Science are not for them. You can see that child very clearly. Normally the marks are low and the child does not show interest and the subject is something very difficult for the child to understand. Also science can be abstract as well. Abstract things are difficult to learners [T2].
>
> I notice that some don't quite do the work and I try by all means to explain and use simple language to make them understand. But I don't know it's because they are second language speakers. So the language could be a problem, a barrier to grasping the concepts and, but I encourage their peers to explain to them, because for some it's the best way for them to learn [T3].

The systemic factors included inadequate resources and equipment while the curricula factors included the abstract nature of science. The factors related to the learners included their aptitude and the language of instruction. The perception of the teachers is that these factors may have contributed collectively to the view that the science/applied science stream should be avoided. These explanations are consistent with the views that learners expressed in the quantitative phase that the SAS curriculum stream is difficult and that they have difficulty in understanding science subjects.

Although the literature review in chapter 2 (cf. section 2.4.1.4) indicates that issues related to the medium of instruction may impact negatively on learner interest and on their behaviour in respect of the school curriculum, factors relating to the teachers themselves may also play a role (cf. section 2.4.2.2). Nevertheless, not one of the teachers attributes the lack of interest on the part of the learners in pursuing the SAS curriculum stream to teacher factors. The literature is steeped in evidence that factors related to such issues as teacher attitudes (Bhana, 2005), and teaching styles (Fenemma, 1990) may dissuade learners from taking up a particular course or subject. Nevertheless, in view of the fact that the majority of the learners experienced the teaching or pedagogy of their teachers in a positive way, it could be argued that the “ability” of learners may provide a better explanation of the challenges confronting these learners.

However, the conviction that the factors behind the learners’ behaviour reside outside themselves as teachers allows the teachers to distance themselves from the outcome of learner behaviour. Attribution theorists have provided an explanation of the abovementioned behaviour of teachers. Attribution theory explains the way in individuals perceive the causes of both their behaviours and the behaviours of others (Weiner in Schunk, 2004:352). People either believe that outcomes occur independently of how they behave, or else they are contingent on their behaviour (Rotter in Schunk, 2004:352). The reactions of the teachers suggest that they believe that outcomes do occur independently of how they behave. The responses of these teachers is consistent with the responses of the learners response in the study in terms of which they acknowledged that their competence in Science and Applied Science did play a role in their consideration of whether or not to pursue the curriculum stream The evidence regarding the reactions of the teachers interviewed is significant because it may be argued that their reactions, if not taken into consideration, have the potential to limit any strategy adopted in order to promote the SAS curriculum stream in schools.

However, some of the teachers did explain that they had tried to encourage all their learners both to pursue the SAS curriculum stream and to bring about a change in the perception that the SAS stream is difficult. Nevertheless, the teachers failed to explain precisely what this ‘encouragement’ entailed. The following comment is fairly typical:

> I encourage them [learners] as much as possible. Unfortunately you always get, when it comes to Natural Sciences – the physics and chemistry – a situation where bright learners do well in these subjects and all the weaker learners tend to battle with them, no matter how you try to make it easy for them [T2].

It would appear that there is a psychological division of the class into learners with high ability and learners with low ability in the grade 9 SAS related subjects. Ironically, although one of the teachers explained that she encouraged learners to pursue the SAS stream, there is evidence in the literature which indicates that the division of learners into ability groups within the same class often discourages, rather than encourages, learners. Reviewers of the countless studies conducted since the 1920s (Sukhnandan & Lee, 1998; Esposito in Abadzi, 1984) have arrived at the conclusion that, although this practice may sometimes helps superior learners, it does tend to prejudice the more inferior learners. Of particular concern is the social stigma attached to those learners who are labelled as having low ability and the possible effects of this on self-esteem and juvenile delinquency (Ireson & Hallam, 2001). It is essential that teachers be sensitised to the negative outcomes associated with viewing their learners in terms of ability so that their message of encouraging learners to pursue the SAS curriculum stream does not conflict with their behaviours as teachers in front of a class.

In support of this statement, theories relating performance changes to reference groups or individual feedback (Bandura, 1982; Sukhnandan & Lee, 1998) predict a decrease in self-concept, achievement motivation, and academic performance for those students who are classified in the low ability groups should these students perceive themselves as belonging to a higher group, particularly if the higher group is visible (Schunk, 2004).

In addition, different groups may become polarised and the extremes stereotyped, thus resulting in specific pressures on learners. In particular, those learners grouped at the less able end of the spectrum have been shown to be removed from positive academic and behavioural role models and are more likely to represent certain members of society. As a result, the characteristics of the ‘bottom set’ may result in reluctance on the part of some teachers to teach this “bottom set” and this, in turn, has been shown to be exacerbated by the fact that the least qualified teacher is often allocated to the least able group (Ireson, Hallam & Hurley, 2005).

The above findings have been highlighted to indicate that it is not possible for teachers to promote SAS as a curriculum stream of first choice successfully or to encourage learners to opt for the SAS curriculum stream if they engage in comparing the abilities of learners.

5.3 DISCUSSION OF THE EVIDENCE WHICH EMERGED FROM THE QUANTITATIVE AND QUALITATIVE PHASES

It is evident from the quantitative phase that teachers do show an interest in the physical science and that they involve learners by conducting practical work (cf. chapter 4, table 4.10). Learners enjoy the practical work and teachers may use this practical work to lessen the gap between the genders. If all learners become involved in their lessons, then the gender bias may be erased. During practical work, learners work in groups and, according to Johnson and Johnson (1993), groups are characterised by a positive interdependence in terms of which learners work for each other. During practical work, learners become active participants (Hayward, 2003) as opposed to the passive onlookers in a teacher centred approach. Webb (2007) argues that practical work stimulates interest and enjoyment and assists in the learning of scientific knowledge. Accordingly, female learners may be attracted to the SAS curriculum stream if they enjoy the teaching approach and there is a chance that their knowledge will be enhanced. Unlike the teacher-centred approach in most schools in South Africa (Gaigher et al, 2006) and elsewhere (Boaler et al, 2000), a learner-centred approach may break down the “masculine” barrier because the learners will all be actively involved in class as opposed to being passive onlookers. This learner-centred teaching approach which allows all learners to participate in lessons may be a motivational factor for learners to like Science and Applied Sciences.

It is essential that teachers realise that English as the language of learning and of teaching may constitute a barrier to some learners and that they, therefore, need to accommodate all learners in their lessons. Code switching at times may be a solution (Setati, 2003), especially as the Eastern Cape is a predominantly isiXhosa speaking region. Science and Applied Science are both abstract in nature and this makes it difficult for some learners to understand these subjects. Accordingly, teachers need to concretize these subjects by making use of models and everyday life examples. This is possible because Science and Applied Science are always present in the world around us and, if learners are able to attach meaning to certain phenomena around them, this will facilitate their understandings of the subjects of Science and Applied Science. Well-resourced schools may also use electronic media such as the Internet and television in order to explain certain concepts in a more effective way and make them more meaningful. However, although most township and rural schools are under-resourced, nevertheless, it is incumbent on the teachers in these schools to teach the concepts and to make learners understand these concepts in the same way as the learners in well-resourced schools, and, thus, in such cases, teachers are forced to improvise by using the equipment available. If possible, they may also borrow equipment from neighbouring schools.

It is essential that teachers demonstrate to their learners the need for greater participation in the SAS curriculum stream in South African schools, and that they inform their learners about the extensive work opportunities available in the fields of Science and Applied Science. If possible, teachers should invite people with whom the learners are acquainted and who have studied the Sciences at tertiary institutions so that these individuals may motivate learners as living examples. Each province hosts a science week every year and, if the schools were able to take their learners to these expos, especially the female learners to motivate them, the gender gap may be closed. Universities also hold expos and it is at these expos that the learners could learn more about possible in the fields of Science and Applied Science.

Literature has shown that females in leadership roles, interaction with staff and social integration are all predictive of sex-atypical curricula and career choices on the part of female learners (Sax & Bryant, 2006: 52-63). It is essential that girls also become members of the learner representative councils (LRC) and that they also be given the opportunity to act as president in order to boost their confidence. This confidence may rub off on their studies and they will realise that, if boys are able to succeed in the SAS curriculum stream, so are they. Teachers must ensure that they interact with the female learners in the same in which they interact with the boys, both within and outside of the classroom. This will enable to girls to realise that they are as good as the boys in every respect at school and this may enhance the performance of the female learners in the SAS curriculum stream.

5.4 SUMMARY

The purpose of the follow-up qualitative study was to determine the reactions of grade 9 teachers in respect of the issues raised by the learners who participated in the study. The evidence from the qualitative interviews suggests that teachers do present the SAS subjects from a practical perspective, which learners enjoy. Although some learners had signified their intention not to select the SAS curriculum stream in Grade 10, either for personal reasons or as a result of external factors, the teachers argue that they are trying, with everything at their disposal, to encourage as many learners as possible to opt for this stream.

The next chapter will cover the conclusion to the dissertation, as well as the implications of promoting science and applied science as a viable stream. The chapter will also include recommendations for further research.

CHAPTER 6

CONCLUSIONS, IMPLICATIONS AND LIMITATIONS

6.1 INTRODUCTION

This chapter discusses the conclusion of this research, and the implications of the evidence for promoting science and applied science as a viable stream. The chapter also includes recommendations for further research and outlines limitations of the study.

6.2 CONCLUSIONS AND IMPLICATIONS FOR PROMOTING SCIENCES AND APPLIED SCIENCES AS VIABLE CURRICULUM STREAM

6.2.1 Conclusion

This study comprised an investigation into the determinants of Grade 9 learners' intention to select Science/Applied Science as a curriculum stream in Grade 10. In general, it is shown that there is no single determinant influencing grade 9 learner's intention to follow SAS curriculum stream; rather, multiple determinants which are both intrinsic and extrinsic in nature. Consistent with the literature, the intrinsic factors were more the influential determinants than extrinsic, which is understandable given the general perception that science is difficult. Factors both inside and outside learners' locus of control deterred them from following the SAS stream. Sociological, economic and personal dynamics seem to account for these patterns in the findings. The greater influence of internal locus of control in deterring learners from following the SAS curriculum stream is corroborated by evidence in attribution and self efficacy theories (cf. Pg 49-64). What is quite significant here is that the learners were inclined to look within themselves for the reasons that deterred them from SAS curriculum stream.

Demographic factors played a crucial role in the way learners think about their grade 10 SAS curriculum stream. The greater interest among boys to pursue the SAS was unsurprising and consistent with the literature, which consistently shows that boys are more inclined to pursue SAS curriculum stream than girls. But what is particularly interesting is that within the study context, more learners in schools located in townships – which are usually under-resourced – had the/an intention to follow the SAS curriculum stream, compared to learners who attend schools in town/urban areas, which are better equipped and resourced. This could reflect wishful thinking, or a degree of ignorance regarding the kind of facility requirements for science teaching, on the part of those township school learners.

Furthermore, gender factors played a role in the attractors/deterrents to the SAS curriculum stream. In general the gender groups were attracted to the SAS curriculum stream for more or less the same reason. Only peer group and career related factors significantly separated the gender groups, which are consistent with the literature. The influence of practical work as a factor in learner motivation to follow the SAS stream did not surprise the educators.

6.2.2 Implications for promoting Science/Applied Science as viable stream

The evidence of the study raises a number of implications for the promotion of SAS as a viable curriculum stream. Evidently the continuing lower participation of girls than boys in the SAS curriculum stream suggests there is a segment of females in the school population whose creative energy and scientific mind is not being tapped into. The nature of the labour market in South Africa, and globally, is changing and girls can no longer rely on a limited range of occupations (which, for females is usually the traditional non-science, e.g. secretarial, teaching and hotellery, ones). Within the South African context, an increasing number of occupations are technical or science-based, and unless females are encouraged at the school level to access the sciences, they will continue to be excluded from science-based employment.

- *Strategies to increase girls' participation in SAS*

Schools must find strategies to increase girls' participation in SAS. They can start doing this by showing the link between science and careers. They also should develop strategies to counter the male stereotype in science. A key implication of this research is that there are a variety of leverage points for attracting more female participation and improving teaching. School leaders and teachers must talk about the way science is taught, its relevance and application to make it more interesting to learners. As part of promoting science, schools must have role models who visit school on a regular basis to talk about science and careers in science. Furthermore, schools should lobby government for more female teachers in SAS, who can be role models for female learners.

- *Career guidance*

The approach of having career guidance to assist learners to make decisions about their subject stream cannot continue in its present form, whereby an event is held on a particular day. There is a clear need for a more structured and ongoing strategy to expose learners – from as early as the beginning of grade 8 (instead of the current end of grade 9) – to SAS role models within/outside the wider community, and SAS related careers. The school should involve parents through SAS awareness programmes so that parents can encourage their children to follow the sciences.

- *Teaching and learning*

The evidence of the study clearly calls for a new approach to SAS teaching and learning – one based on experiential learning. Thus, the manner in which science is presented should now emphasise practical work because this has shown to be a major attractor to learners. This new approach to teaching/learning has wider school infrastructure and facility implications. For instance, rural township schools with limited facilities and without resources will need to have these in place for meaningful experiential teaching/learning to take place. Of course, this is a political question but one which must be addressed.

- *SAS curriculum and capacity building*

There is a need within the school context to identify the range of factors that are deterring learners from following the SAS stream. As this study has found, many learners do not enjoy science or applied science because they find it rather difficult and irrelevant to their life course events. To develop an effective strategy to promote the SAS as a viable stream, curriculum developers at the school level need to further understand the underlying challenges learners face. This is a critical first step to promoting the curriculum. Once an in-depth understanding of these challenges is documented, a relevant strategy to build both teacher and learner capacity to teach and learn science can be devised. Reducing learner perception, as well as their actual experience, of science difficulty is paramount to increasing participation in SAS, especially among girls.

- *Wider school community and policy*

The Department of Education, in collaboration with the Department of Science and Technology, should embark on rigorous road-shows to promote the SAS curriculum stream. Education Developmental Officers (EDOs) should ensure that teachers adhere to the policy documents in terms of their teaching strategies (using practical work) by carrying out regular inspections in schools. As evidence from the teacher interviews indicate, language difficulty also deters learner participation in SAS. The language policy in terms of the teaching and learning at secondary school level may need to be revisited to accommodate the learners' home languages. At an ethnic group level, ways to improve greater participants among white learners who attend public school are required. EDOs can engage the parents of these learners through parent meetings.

6.2.3 Further research

The disparities in terms of gender involvement in the sciences and applied sciences come about as a result of deeply entrenched socio-cultural constructs such as belief that science is masculine domain. There needs to be research conducted to ascertain ways in which to erase these stereotypes and socio-cultural constructs as this might mean the leveling of the playing field in respect of both the science and the applied sciences for both genders.

In terms of race, most of the white learners revealed that they did not intend to opt for the science and applied science stream, despite attending well-resourced schools. Further research could be conducted to explore the career pathways of these learners, as well as that of Indian learners who all have a keen interest in following the sciences.

Learners from the township schools also indicated that they intended to opt for the science and applied science stream despite that the fact that their schools had extremely meagre resources. It may be they are intending to pursue the science and applied science stream because they want to find better jobs after school and also because there are bursaries available for needy, promising learners in the science fields. However, further research needs to be undertaken in order to ascertain the reasons for the township learners' intentions to opt for the science and applied science stream.

In general, it would be meaningful to have a tracer study of these grade 9 learners to see what proportion of them actually select the SAS stream and whether they do persist to grade 12 or dropout out of the stream at some stage. This could better inform the SAS promotion strategies develop by schools.

6.3 LIMITATIONS

Two key limitations of this study need to be noted. The first is that the research was a case, involving a sample of Grade 9 learners drawn conveniently from five schools. Consequently, the findings, particularly as they relate to gender and racial groups, cannot be generalised. Secondly, the inexperience of the researcher in conducting a study of this nature, particularly interviewing participants for the qualitative phase of the investigation, proved to be a limitation as he was doing this extensive research work for the first time. The inexperience may have resulted in gaps in data collection and analysis.

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APPENDICES

APPENDIX A

Letter requesting permission to access the schools

APPENDIX B

Letter from the District Director

APPENDIX C

Questionnaire

QUESTIONNAIRE

GRADE 10 SUBJECT STREAM SELECTION STUDY, 2009

This study aims to provide information on Learner Stream Selection for Grade 10. It seeks to understand the different subject streams that you intend to pursue in grade 10. The study is being done for a Master's Degree in Education.

KINDLY NOTE THE FOLLOWING:

- Complete all questions as honestly as possible. Do not leave out any question.
- There are no right and wrong answers.
- The questionnaire is anonymous. And strict confidentiality is promised. Your identity and the research sites will not be revealed.

SECTION A: BIOGRAPHICAL AND SCHOOL PERFORMANCE DATA

Kindly fill in your data in respect of all the characteristics listed below by ***circling*** the relevant RESPONSES

1. Your ***gender***:
   - Male……………………………. [1]
   - Female………………………… [2]

2. Your ***age group***:
   - 12years or younger …..………... [1]
   - 13–15 years …..………………… [2]
   - 16years or older…...…………… [3]

3. Your racial/ethnic ***group***:
   - Black …………………………. ……….. [1]
   - White ………………………….. ………. [2]
   - Indian………………………………….... [3]
   - Coloured …………………….. ……….. [4]
   - Other (specify) ________________ [5]

4. Your home ***language***:
   - IsiXhosa……………………………….. [1]
   - IsiZulu ……………………………….. [2]
   - English ……………………………… [3]
   - Afrikaans ………………………………. [4]
   - Any other (specify) ______________ [5]

5. At home, with whom do you ***live***:
   - Mother only ……………………………. [1]
   - Father only …………………………….. [2]
   - Mother & Father ………………………. [3]
   - Other (Specify): ________________ [4]

6. WRITE the ***highest*** level of education of the person(s) with whom you are living:

   ____

7. Your school is located in a:
   - Rural village …………………………. [1]
   - Township ………………………........... [2]

Town …………………………………..   [3]
Farm …………………………………...   [4]

8. My school is a/an:
All boys school ………..…………… ….   [1]
All girls school ……………………………   [2]
Boy and girl school…………………..   [3]

<u>SECTION B:</u> GRADE 10 SUBJECT STREAM SELECTION

9. What career (or further studies) do you intend to do after grade 12? (please specify): ______________________

10. Will you select the Science and Applied Science subject stream in grade 10?
Yes ………………………. …..   [1]
No …………………………….   [2]

NB: If your answer to question 10 is YES, go to section C. If your answer is NO, go to section D.

<u>SECTION C:</u> PULL FACTORS (ATTRACTORS) TO SELECT SCIENCE/APPLIED SCIENCE AS SUBJECT STREAM

Tick the responses which best reflect your feelings toward each of the statements below.

No.	**STATEMENTS**	**RESPONSES**				
		Strongly Agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
11	I intend to select the Science and Applied Science stream because it has practical work which I ***enjoy***					
12	I intend to select the Science and Applied Science stream because I ***love*** the Sciences and Applied Sciences					
13	I intend to select the Science and Applied Science stream because I always get ***good marks*** in the Sciences and Applied Sciences					
14	I intend to select the Science and Applied Science stream because I want to ***become*** a ***scientist***					
15	I am ***confident*** that I will do well in the Sciences and Applied Sciences Subjects in grade 10					
16	I intend to select the Science and Applied Science stream because ***my friends*** are intending to do the Science and Applied Science stream in grade 10					
17	I intend to select the Science and Applied Science stream because I know ***people*** who are involved in the science related fields					
18	I intend to select the Science and Applied Science stream because the ***people*** I know in this field are doing well in their career					

19	I intend to select the Science and Applied Science stream because my ***teachers*** show interest when it comes to teaching Science lessons					
20	I intend to select the Science and Applied Science stream because my ***parents*** are encouraging me to do the Sciences					
21	I intend to select the Science and Applied Science stream because the ***job market*** needs more people in the Science field					
22	I intend to select the Science and Applied Science stream because Science related jobs are the ***best paying*** ones					

List any other reasons for your intention to select the Science and Applied Sciences Stream in Grade 10

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<u>SECTION D:</u> PUSH FACTORS (DETERRENTS) FOR NOT SELECTING THE SCIENCE AND APPLIED SCIENCE AS SUBJECT STREAM

Tick the responses which best reflect your feelings toward each of the statements below.

No.	STATEMENTS	RESPONSES				
		Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
23	Sciences and Applied Sciences stream have no relevance to the ***career*** I plan to follow					
24	I am discouraged to do science /applied science because I always get ***low marks*** (i.e. don't pass it)					
25	I am discouraged to do science /applied science because I ***don't understand*** it					
26	I am discouraged to do science /applied science because I ***don't see how*** in real life to apply the Sciences I learnt.					
27	I am discouraged to do science /applied science because I ***don't enjoy*** it					
28	I am discouraged to do science /applied science because the ***terminologies*** are not what we use in everyday life.					
29	I am discouraged to do science /applied science because it takes a long time to ***read*** it					
30	I am discouraged to do science /applied science because ***my parents don't*** want me to do it					
31	I am discouraged to do science /applied science because I find the ***Sciences too difficult*** (memorise so many rules and laws).					
32	I am discouraged to do science /applied science because my teacher is ***unfriendly*** in class.					
33	I am discouraged to do science & applied science because my ***teacher disallows me to take part in practical work***					

34	I am discouraged to do science /applied science because my teacher gives us ***opportunities*** to discuss Science and Applied Science concepts.					
35	I am discouraged to do science /applied science because my teacher shows love for the subject during teaching					
36	I am discouraged to do science /applied science because ***too much competition among boys is*** in the class.					
37	I am discouraged to do science /applied science because I have ***no Science role*** models in my community/village.					

List any other reasons for your intention ***NOT*** to select the Science and Applied Sciences Stream in Grade 10

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APPENDIX D

Response sheet

APPENDIX E

Letter from principal

APPENDIX F

Interview questions and script

TEACHER INTERVIEW

TEACHER 2:
GIRLS' SCHOOL: Former model C

Q1. 78,3% of the learners will choose SAS because they enjoy practical work. Explain how do you conduct practical work such that learners can enjoy it?

T: They get a pract report sheet, to read upon when they come in. They are given 10minutes to read. If the pract is safe enough they get a chance to do it on their own. Apparatus are set before they come in. After they have read the pract they know how to carry on with the method, and they do the experiment. They obtain the results and they draw up conclusion.
If it is a major pract, they have to formulate their own hypothesis. They are given apparatus they write investigation question, also design, their own experiment. Then they formulated their findings.

Q: Who set up the apparatus for them?

T: I normally set up the apparatus. If it is more difficult I set up myself. If it is dangerous like burning, I do a demonstration.

Q: During a demonstration do they have time to ask questions?

T: The pract worksheet covers all the questions, they have to first read. When I do the experiment, I discuss things with them. So I give a lesson with a pract. Listening is an important part of learning task from the worksheet they should know the questions and the answers from the pract. I don't give them answers.

Q: How do you make sure that learners in groups are all involved?

T: Sometimes it happens that one being dominant, but as much as possible what I encourage them to do is that everybody must gat a chance to say her opinion, everybody must be accepted. You do not take one person's opinion as the truth. Everybody contributes. I try to balance the groups I do not put all top learners in one group. If you have one group with a bright learner, that learner tends to get things rolling. If you have a group of all weak learners then they don't know where to start. The bright learner starts them off and everybody gets a chance to be hands on.

Q2. 63.1 of the learners will choose SAS because the teacher shows interest in science. How is your teaching strategy that makes learners to see that the teacher is showing interest in the subject?

T: If you show love for the subject and the knowledge is there. Also if you walk in a class with a textbook in your hand and you are constantly reading, that shows you do not know your subject. If you walk in a class, you teach and the lesson flows, the kids know. At the same time your lesson should not only be what the syllabus requires because you got to stimulate the children. You got to tell them things that they want to know. They are more interested in the things that are not in the syllabus. You tell them more, that will make life more interesting, make the subject more interesting and you find out they tend to like it. Like I was teaching my girls reproduction, being a man it is a very difficult thing. But it was fantastic, they were asking questions they will not ask to their parents and they wee getting the answers. They were happy because they were now learning things they did not know before. Going above the syllabus, not just adhering to it is the Ok thing to do.

Q.3 39.2% will not choose SAS because they do not understand it. Do you realize that some learners do not understand science?
T: Being a science graduate, I see that some learners discover in grade 9 that Maths and Science is not for them. You can see that child very clearly. Normally the marks are low and the child does not show interest and the subject is something very difficult for the child to understand science. Also science can be abstract as well. Abstract things are difficult to learners.

Q: Are you doing anything to change that thinking/perception that science is difficult?

I encourage them as much as possible. Unfortunately you always get , when it comes to Natural Sciences, the physics and chemistry, you find bright learners doing well in them and all the weaker learners tend to battle with it no matter how easy you trying to make it easy for them. That gives a good indication what comes up in grade 10, whether the learner is equipped with it, because when a learner gets to grade 10, it is too late to go back and teach the child. The basic concepts are done in grade 9. It's difficult to understand in grade 10.

Q4. 50.7% of the learners will not choose SAS because they do not enjoy science. Do you see that some learners do not enjoy science?

T: Yes most of them tend not to enjoy it especially the physics and the chemistry part. As far as biology part, they are always involved. You can see that you can relate biology to what they know and they enjoy that but it is difficult for physics to do the same. They cannot understand the concepts of atoms, electrons, protons and neutrons because they require abstract thinking. Some learners never pick up that matter is made up of atoms because they cannot see atoms.

Q5. 52% of the learners will not choose SAS because they perceive it as a difficult subject. What are you doing to change this perception?

T: Teaching strategies can but unfortunately the time we have available does not make it easy because if you look at DoE requirements and the work to be done, wee actually fight for time. Another time you find out that what you are requires to do and how you can actually do it, you know does not relate. Look at the syllabus in grade 10, 11 & 12, there is no much time to focus on practical work although practical work is an important task. One experiment with 32 kids in class will take about two to three lessons and if you will do 10 experiments a year you have 30 lessons of practical work, which is equivalent to six weeks of teaching, that is only gone on practical work, so that leaves you with other remaining weeks for teaching. So this does not make it easy. The best way of understanding SAS is group work. But group work can be an added burden of time because what you can teach in one period, takes you two to three periods by using group work, time is also a problem.

Q6. 70.9% of the learners won't select SAS although they think that some teachers are friendly? What could be the reason for not choosing science?

T: I think the difficulty of the subject makes it absolutely an easy choice for them. T I think they realize that science involves slightly higher thinking. If you look in the current matric papers you will see that the level of science is higher that the level of the Maths paper. That is an indication of where science thinking is. So to do science you have to be one of those top pupils that can actually think and increase the level of thinking to a new level. If they realize they cannot do it, they opt out of it. It is a good choice at the end because a lot of them, they tend to battle. If they do choose the subject they are bottleneck cases. If they score 50% in Natural Science in grade 9, in grade 10 they cannot cope.

Q7. Although you allow them to participate in practical work, 74.3% of the learners still will not choose SAS. Are your experiments challenging enough?

T: The reason behind I think……. The experiments are challenging enough because they involve sight, what they can observe, sometimes sense of sound (hearing), like gases production (hydrogen gas pop sound). Sometimes we may look for precipitation. The difficult thing is to take all that and put it into a chemical equation. Even if things are in-front of them, it is a matter of them to put everything together, they cannot do it. So it's not that it is not challenging enough. When it is too challenging, you know, it puts them off.

Q: Does it not go back to the theory that as supposed to be taught before the experiment?

T: They actually do that before they carry the experiment, because it is part of the syllabus as well. They are shown how simple molecules are formed, like carbon and oxygen forming carbon dioxide. So the knowledge is there it is just a matter of applying it.