ATTITUDES AND OCCUPATIONAL SEX-ROLE STEREOTYPES RELATING TO NATURAL SCIENCE STUDIES IN HIGHER EDUCATION AMONG RURAL BLACK FEMALES

by

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Bloemfontein

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CO-SUPERVISOR: Prof A C Wilkinson (PhD)

December 2009

DECLARATION

I declare that the dissertation hereby handed in for the qualification Philosophiae Doctor (PhD) at the University of the Free State, is my own independent work and that I have not previously submitted the same work for a qualification at another University/faculty.

PP Makate .... Date...................................

ACKNOWLEDGEMENTS

I wish to thank all my PhD lecturers for providing me with knowledge and support throughout all my studies.

My sincere gratitude goes to my supervisors Dr M C Viljoen and Prof. A C Wilkinson for being so supportive and patient in giving me direction and leading me throughout my studies. I envy their hard work. May God bless them.

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The standardised measuring instruments used in this quantitative study were the Science Attitude Scale for Middle School Students and the Occupational Sex-Role Stereotype Questionnaire. Data was analysed using univariate and multivariate statistics.

Results in this study revealed that the academic achievements of Black Grade 12 female learners in biology, physical science and mathematics were poor in Grade 11. The results showed that there were no significant relationships between science attitudes, occupational sex-role stereotypes and the marks in biology, physical science and mathematics. All P-values were greater than 0.05. In the case of marks in biology and physical science, the confounding variables (ethnicity, age and psychosocial factors) did not have a significant effect on the dependent variable. However, in respect of the dependent variable (marks in mathematics), age and psychosocial background factors both had a significant effect, but not ethnicity. It was interesting to note that ethnicity was not a significant confounder, because the P-value was greater than 0.05. However, the t-test indicated that the performance of Xhosa females in science (consisting of their total marks in biology, physical science and mathematics) was better than that of the South Sotho females.

Recommendations for various stakeholders were presented. They include: creating classroom environments that spark initial curiosity and foster long-term interest in biology, physical science and mathematics, providing spatial skills training, helping learners to structure appropriate study habits and to develop identities as learners,

exposing learners and students to laboratory work in university chemistry and in schools, increasing parental involvement, providing teachers with mentorship programmes in the teaching and learning of biology, physical science and mathematics, preparing secondary school learners for higher education and improving educator qualifications in biology, physical science and mathematics.

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Black learners

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South Africa

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School teaching

OPSOMMING

Die doel van die studie was om die verwantskap tussen houdinge jeens die natuurwetenskappe, beroepsgeslagsrol-stereotipes en die toetrede van plattelandse Swart vroulike leerders tot natuurwetenskaplike studies aan hoer onderwysinstellings te ondersoek. Op hierdie wyse is gepoog om meer lig te werp op faktore wat vroulike persone in Suid-Afrika moontlik verhinder om sodanige studies te volg of tot loopbane in natuurweteskaplike beroepe toe te tree. Die steekproef het bestaan uit 112 Swart vroullike graad12-leerders uit vyf plattelandse skole in die Xhariep-distrik in die Vrystaat. Die punte wat behaal is in biologie, natuur- en skeikunde en wiskunde is beskou as die kriterium vir toetrede tot natuurwetenskapstudies. Die punte is verkry uit die resultate vir die graad 11-eksamen van November 2008.

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Natuurwetenskapstudies

Wetenskaphoudinge

Beroepsgeslagsrol-stereotipes

Akademiese prestasie

Swart leerders

Vroulike leerders

Etnisiteit

Suid-Afrika

Vrystaat

Skoolonderwys

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CASE	Community Agency for Social Inquiry
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DoE	Department of Education
DST	Department of Science and Technology
FET	Further Education and Training Band
FSDoE	Free State Department of Education
GET	General Education and Training Band
HE	Higher Education
HESA	Higher Education South Africa
HET	Higher Education and Training
HG	Higher Grade
HSRC	Human Sciences Research Council
ICT	Information and Communication Technology
NCS	National Curriculum Statement
NRF	National Research Foundation
NSF	National Science Foundation
RAU	Rand Afrikaanse University
R&D	Reconstruction and Development
RSA	Republic of South Africa
SAASTA	South African Agengy for Science and Technology Advancement
SES	Socio-economic Status

SAQMEQ	Southern and Eastern Africa Consortium for Monitoring Educational QualityStudy
SAT	Scholastic Assessment Test
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LIST OF APPENDICES

OVERVIEW OF THE THESIS

Chapter 1

This introductory chapter provides an orientation and background of the study as well as a brief outline of the quantitative research methodology employed.

Chapter 2

The second chapter provides a literature study regarding the representation of Black women in science, engineering and technology (SET). This chapter highlights specific statistics indicating that women in general, and Black women in particular, are grossly under-represented in the SET fields of study and careers.

Chapter 3

This chapter highlights factors that influence vocational choices of Black girls. A variety of factors such as cognitive and non-cognitive factors are highlighted. This chapter will also highlight that the literature review consulted, indicates that although much international research has been undertaken in this regard, there seems to be a few empirical studies within the South African context.

Chapter 4

Chapter four provides the implementation of the research. This chapter highlights the background to the research rationale by stating the research problem and the hypotheses. The aims and objectives of the study are provided and the dependent, independent and confounding variables are identified and operationally defined. Data collection techniques and analyses are provided in which a univariate and a multivariate analyses are employed. The objectives of the statistical analyses are highlighted. The chapter also informs the readers about the reliability and validity of the research results.

Chapter 5

In the fifth chapter the findings of the results are reported and discussed. Descriptive analyses of confounding, independent and dependent variables are provided. Analyses of association are highlighted in which a univariate and a multivariate analysis are provided. The chapter concludes with a discussion and a summary of the quantitative research results.

Chapter 6

The last chapter provides a summary of data and draws conclusions, makes recommendations and indicates the limitations of the study. Conclusions drawn from the literature study and from the statistical analyses of the research results are highlighted. Recommendations which could be employed by the South African government and the Education Department are suggested. The chapter closes with the limitations of the study and conclusions.

CHAPTER 2

THE REPRESENTATION AND PERFORMANCE OF BLACK WOMEN IN SCIENCE, ENGINEERING AND TECHNOLOGY: COMPARATIVE PERSPECTIVES

2.1 Introduction

The research data on the representation of women in science, engineering and Technology, (SET) are very interweaved. In different kinds of studies the position of Black women in science is compared to that of men, other races and Whites. As a result it becomes difficult to compare these studies. Reference is made to a number of secondary sources because the information was important and the original sources could not be found. The types of resources consulted included books, internet articles, journals, papers, reports, unpublished dissertations and government publications.

The literature review of South African origin covers both mathematics and physical science as subjects offered in the higher grade (HG) and the standard grade (SG) in grade 12 according to the old curriculum. When the senior certificate was replaced by the national senior certificate in 2008, mathematics became compulsory while physical science remained an elective subject (Bernstein 2007: 31). Learners were required to write either mathematics or mathematics literacy. Furthermore, the differentiation between SG and HG was phased out.

According to Moletsane and Reddy (2008: 13) even though there is substantial literature regarding the engagement of women in SET a large part of it comes from the developed countries. Moletsane and Reddy (2008: 13), citing research conducted by Campion and Shrum (2004), believe that empirical studies exploring the effects of gender representation in SET are limited. Therefore it is difficult to determine the influence of gender on SET in the South African context because of the scarcity of literature in this area of interest (Moletsane & Reddy 2008: 9). The Centre for Research on Science and Technology (CREST 2005: 15), referring to studies conducted by Oldham, (2000) confirms that this is a global problem since what many countries appear to have in common is "…the lack of reliable, comprehensive and comparable sex-disaggregated data which is critical in enabling policy makers and planners to assess the status and profile of women in SET".

The aim of this chapter is to give a picture of the current situation of Black South African females in SET fields of study and careers as seen against the background of international studies on these aspects. As such the following questions direct the literature review:

- Is the position of Black women in SET in South Africa the same as or different from that of Black women in other countries?
- How does the position of Black women compare with the position of Black men in South Africa? and
- How does the position of Black women compare with the position of White women in South Africa and worldwide?

2.2 Comparative perspectives on the interest and performance of Black females in SET in South Africa

In this section, a comparison will be made between relevant findings and perspectives from literature which involves gender and racial differences as well as possible national/international variations. As far as possible, perspectives will include the school sector, higher education and career information. The discussion commences with perspectives on the diminishing interest in SET worldwide.

2.2.1 Diminishing interest in SET worldwide

Globally, there have been debates about the lack of interest of students in general in careers in the SET fields. Babco and Golladay (2001: 19 of 96 & 27 of 96), Frehill, Ketcham & Jeser-Cannavale (2005: 34) and Loya (2000: 27) document that the science and technology (S & T) workforce in the United States is growing old and that enrolments of students in the USA, have been declining for several years in these fields, especially in physical science, mathematical sciences, engineering and computer science, while dramatic increases have been noted in the biosciences and health fields.

As such, during the late 1980s the National Science Foundation (NSF) projected a “looming shortfall” of scientists and engineers towards the end of the 1990s in the USA (Teitelbaum 2001: 72 of 96). What is disturbing, according to Chubin and Pearson (2001:12 of 96), is that the need for a science and engineering workforce is anticipated to escalate three times more quickly than other professions. According to Gatta and Trigg (2001: 2), there is a dire need for computer scientists, engineers as well as programmers in the United States. As a result, there are about 190 000 vacancies in Information Technology, and there is a likelihood that this figure will increase, producing about 5.3 million new jobs to be filled by the year 2008.

In many countries, after spending a number of years in secondary science education, many students do not continue to study science at higher levels and most dislike the subject (Gough 2007: 27). According to Trumper (2006: 49), in Israel less than 25% of students in secondary schools major in science and there is a significant drop in enrolment figures as compared to those in the 1980s because about half of the senior students did not enrol for the sciences in that country. Trumper (2006: 49), citing studies conducted by Osborne et al. (2003), mentions that in England and Wales enrolments of science students dropped by more than 50%, from the 1980s to the beginning of the 2000s. In Nigeria, although the number of institutions that present engineering programs has multiplied dramatically, the standard of engineering education has deteriorated radically due to dwindling interest in SET among school leavers (Kofoworola 2004: 23).

The findings from this literature review suggest that on a global scale there is a general diminishing of interest among school learners and students in general in the study of science, engineering and technology. This diminishing interest can be observed from the secondary school level through to higher education institutions. If this trend continues the implication is that the world will not be able to meet the challenges of the new scientific and technological era with the small scientific workforce pool available.

2.2.2 Comparison of South Africa with the rest of the world regarding interest and performance in SET

The Department of Science and Technology, (RSA DST 2006: 6) argues that South Africa is challenged by low participation of students in SET, and a dwindling scientific research population. As a result, Women in Science (2003-2007: 1) citing research done by Lawless (2005), indicates that there is a dearth of substantially proficient men and women in specialised SET fields. According to the Facing the Facts study (RSA DST 2004: 6), South Africa's future SET workforce will be drawn from the small pool of doctoral students in technikons and universities. De Jager (2000: 19) indicates that in most SET faculties the number of technologists is anticipated to grow only at a rate of 10% which must not only meet the demands of the developing economy but must be able to compete globally. The sad news is that the number of engineering candidates is plummeting across South Africa and graduation rates are also not promising (Jawitz 2000: 17). South Africa finds itself in the same dilemma as other countries in the world regarding interest and performance in SET.

Because the acquisition of science and mathematics skills has become a worldwide concern, South Africa participated in Trends in International Mathematics and Science Studies (TIMSS). TIMSS seeks to compare the performance of American learners in mathematics and science to that of learners in other countries (Bernstein 2007: 33). Results from TIMSS collected in 1995, 1999 and 2003 document that South African learners were performing badly in mathematics and science when compared to learners in other countries. In 2003, 45 countries participated in a TIMSS survey and South Africa was ranked last (Bernstein 2007: 34). These countries included African countries such as Botswana, Tunisia, Egypt, Morocco and Ghana. Commenting on these results, Hofmeyr (2006: 6) acknowledges the crisis in mathematics and science education in South Africa.

A closer examination of the Xhariep district grade 12 mathematics and science statistics in 2006 in the Southern Free State indicates that out of the 22 secondary schools, there were 21 entries in mathematics HG with 17 passes, and out of 273 SG entries, 193 candidates passed. In physical science HG there were 48 entries and 29 candidates passed, while for SG there were 185 entries and 140 candidates passed. The statistics, however, do not indicate the overall number of learners who sat for the grade 12 examinations in 2006 in the

Xhariep district (RSA FSDoE 2006: 1 of 19). These statistics (although data are not available for 2007 and 2008) are an indication of inadequate preparation of the Xhariep district population in mathematics and science HG, which according to Smith (2007: 2 of 14), is a requirement for entry into SET fields of study. When looking at the other scientific domains such as the life sciences and physical sciences, it is found that in 2001 women comprised the majority of doctoral enrolments in these domains (RSA DST 2004: 19).

When comparing South Africa with the rest of the world regarding interest and performance in SET, it becomes evident that the SET sector in the country faces difficulties associated with human resources, as is the case internationally. It is also clear that the standard of mathematics and science teaching is far below that of other countries. This could be the reason why the performance of South Africa's learners has been well below standard, as indicated by the TIMSS results, compared to the performance of learners in other countries.

2.2.3 Interest and/or performance in SET of Blacks and Whites in South Africa

In South Africa enrolments for mathematics and science learners in grade 12 have been decreasing over a number of years. Moreover, those who enrol in these subjects in the HG are extremely few (RSA DoE 2001: 8; Horak & Fricke 2004: 14) despite (RSA DST 2006: 11), numerous public awareness programs that have been undertaken and (Bernstein 2007: 23) great efforts which have been made to enhance the increase of learners in mathematics and science in the education system. A number of researchers have looked at the enrolments and pass rates of learners in general in mathematics and science at grade 12. According to Mangena (2002: 3 of 5), the national statistics reveal that Blacks are not doing well in mathematics and science. Hofmeyr (2006: 6) documents that, in 2002, of the grade 12 learners who wrote mathematics and science, less than 5000 were Blacks and only 700 obtained an A, B or C symbol, which is an indication of readiness for entrance into tertiary levels of education. In 2005, out of half a million learners who sat for the grade 12 examinations, 26 383 learners achieved university entrance. The performance of Blacks was still not good. According to Moleke (2006: 5), because very few Black students pass mathematics and science in school, there is a low throughput rate of Blacks at HE institutions in the SET programs.

Subotzky (2003: 1 of 5) states that the country's population totals about 44 million, of which 70% is Black, 16% is White, 10% is Coloured and 4% is Indian. Although Black students' enrolments have escalated between 1993 and 2000 in South African universities and universities of technology (technikons), their numbers in SET programs remain low (Higher Education in Africa 2008: 9 of 19). Pocock (2004: 10) indicates that in the Chemical Engineering field at the University of Natal, the enrolment of Black students in the first year has remained low since 1990.

Lickindorf (2005: 390-392) argues that after the democratic elections in South Africa, discussions were held by the United Kingdom and South Africa. These discussions aimed at assisting previously disadvantaged universities in developing proficiency and status in SET and improving access of Black staff to South Africa's higher education sector, in view of the fact that White teaching staff, are in the majority in this sector. A primary concern in these discussions was that a mere 30% of graduates at bachelor's, honours and master's levels in the natural and engineering sciences were Black, and those obtaining a doctorate degree were at 10%, despite the fact that 84% of South Africa's population was Non-white. Additionally, in 1991 80 % of South Africa's workforce in SET, were White. Mangena (2005: 3 of 4), citing different statistics, confirms that although Blacks account for 90% of South Africa's population, they only form 2% of South Africa's scientific population.

Despite the great numbers of Blacks in South Africa, many Black students still do not enrol in significant numbers in the SET fields of study. Many of them still enrol extensively in the Humanities at HE institutions. Therefore schools which serve the majority of Black learners should encourage Black learners to enrol in greater numbers in mathematics and science.

2.2.4 Interest and/or performance in the SET sector of different race groups in the rest of the world

Racial disparity in SET programs and careers is also evident in other countries. Loya (2000: 35) notes that the numbers of African American, Hispanic, American Indian and Asian graduate students in SET are still disappointing when compared to the number of Whites in SET. According to Kuh (2001: 47 of 96), in Bachelor's degrees to PhDs, Whites and Asian

Americans seem to be more inclined to enrol in SET than are African Americans, Latinos and American Indians. From grades 4, 8 and 12, White and Asian/Pacific Island learners have consistently obtained better marks in mathematics and science at school level than Black, Hispanic and American Indian students (Slashinski 2004: 1) although the gap is shrinking. A report provided by Inside Higher Education (2009: 2 of 5) documents that the number of engineering degrees as opposed to all Bachelors' degrees conferred in America, dropped between 1995 and 2005 for all ethnic groups, with the exception of American Indians and Alaska Natives. This result is different from the previous result with regard to American Indians.

Rosenhall (2007: 4 of 6) indicates that test scores, in the standardised mathematics and English test which is taken annually by learners from grade 2 to 11, show that White and Asian American students performed better than Latino and African American students in these tests. Although there have been overall improvements in performance over a few years, the Latino and African American learners have not shown any remarkable improvements. Inside Higher Education (2009: 2 of 5) reports that the disparity between Black and White educational achievements has lessened over the years "…but not disappeared".

Gatta and Trigg (2001: 23-24) state that racial and ethnic 'minorities' (a term usually associated with East Asian Americans, Indian Americans, African Americans, Hispanics and Latinos) in the United States are confronted by a lack of entry into high quality education in mathematics and science education and in other subject areas during the K-12 years. As a result, minority groups, including Hispanics, African Americans and American Indians, do not perform as well in secondary school as do their White counterparts. It was noticed that where secondary school minority groups' enrolments are high, there are few advanced mathematics and science courses and programs. Citing research undertaken by Smyth and McArdle (2004), Frehill et al. (2004: 28), indicate that persistence rates of 5 074 college students who have indicated an intention to major in science subjects was examined. Research results revealed that at selective education institutions, students with high persistent rates were those who received prior adequate academic preparation in science at secondary school. Asian students had the highest persistent rates and they were followed by White students. American Indians, Hispanics and African American students showed relatively lower persistence rates.

Garner (2008: 1 of 3), offering contrasting results, reports that in the United Kingdom (UK), White learners seem to avoid mathematics and science and believe that successful people in mathematics are naturally gifted, while Asian and Chinese learners believe that what is needed to be successful, is hard work. In chemistry Pakistan and Indian learners are 7.2 times and 4.3 times, respectively, more likely to progress to chemistry A-level than White learners with same level of achievement. In Bangladesh, Black and Chinese learners are more likely to continue to chemistry A level than Whites are. A similar pattern was also seen in mathematics, with Chinese, Indian, Pakistan, Bangladesh and Black learners more likely to progress to mathematics A-level than their White counterparts.

Given these facts it seems as if some ethnic minorities such as African Americans, Hispanics, American Indians and Latinos in the United States of America (USA) find themselves in more or less the same situation as that of Black students in South Africa. Despite their poor performance in science and mathematics they are also confronted with schools which do not provide advanced courses in SET. This situation already hampers their efforts to be on the same footing with their White counterparts in the SET programs and fields of study. As a result parity between ethnic minority students and White students in educational opportunities, especially in SET, will probably not be reached in the near future.

When analysing the study undertaken by Garner (2008: 1 of 3) it is found that the situation in the UK differs from that of the USA. White learners in the UK seem to have negative attitudes towards mathematics and science despite the equal educational opportunities that different race groups might have in that country. They do not seem to have any problems to access educational opportunities in SET fields of study, as reported above. Garner (2008: 1-3 of 3), however does not provide information on the performance of Black British learners in mathematics and science relative to that of White students.

2.2.5 Interest and/or performance in SET of males and females in South Africa

Concerning science as a school subject in South Africa, data supplied by Edusource Data News (2003: 22-23) indicate that the performance of females in mathematics HG in grade 12 improved significantly between 1996 and 2002. At the same time female enrolments in mathematics and physical science were growing more quickly than male enrolments. However, females were less keen to enrol in mathematics HG and rather opted for mathematics SG.

When one examines data supplied by the RSA DoE (2003-2006) they show that the gender gap between males and females in general is closing in participation and pass rates in mathematics and physical science at school level, although statistical data are unavailable for 2007 and 2008. The following statistics attest to this argument:

Table 1: Senior Certificate examination results for Mathematics and Physical Science HG by gender between 2000 and 2006 in South Africa.

Subject	Year	Number of Candidates who Wrote			Number and Percentages of Candidates who Passed				
		Female	Male	Total	Female	Female %	Male	Male %	Total %
Mathematics	2000	18219	20301	38520	11482	63.0	13395	66	64.6
Higher Grade	2001	16707	18163	34870	11989	71.8	13395	73.7	72.8
	2002	16598	18867	35465	11880	71.6	13635	72.3	71.9
	2003	16618	19338	35956	13096	78.8	15597	80.7	79.8
	2004	18120	21819	39939	13480	74.4	16606	76.1	75.3
	2005	20051	24002	44053	14138	70.5	17974	74.9	72.9
	2006	21321	25624	46945	14547	68.2	18565	72.5	70.5
Physical Science Higher	2000	25582	30117	55699	15718	61.4	20565	68.3	65.1
	2001	22311	26685	48996	15482	69.4	19972	74.8	72.4

Grade	2002 2003 2004 2005 2006	22713 23105 24371 27743 31266	28279 28975 31598 34594 38036	50992 52080 55969 62337 69302	16998 17177 17566 19766 20687	74.8 74.3 72.1 71.2 66.2	21912 22827 23952 25886 27683	77.5 74.3 75.8 74.8 72.6	76.3 76.8 74.2 73.2 69.7

(RSA DoE Education Statistics in South Africa 2000-2006).

The table shows that from 2000 to 2006 there have been gender differences in achievement at grade 12 in mathematics and science HG, although not extensively. The percentage of passes for males in both physical science and mathematics HG is somewhat higher than that of females. The male enrolment has throughout been higher than that of females. It must however be noted that these results are for all racial groups representing all types of schools.

According to the Minister of Education, Naledi Pandor (2008: 4 of 5), in 2008 there were positive achievements in mathematics and science in grade 12 although it is not yet clear how females compared with males with regard to pass rates. The Parliamentary Monitoring Group (2009: 1 of 7) further claims that the subjects in which grade 12 learners scored the lowest in 2008 were accounting, agricultural science, mathematics and physical science. Females generally performed better in most subjects except in agricultural science, geography, history, mathematics and physical science. No Improvement in Matric Maths (2009: 2 of 3) indicates that, despite the positive achievements in mathematics and science of grade 12 learners in 2008 as reported by Naledi Pandor above, about 60% of students had still not performed well in mathematics. By contrast, there was an extremely high pass rate in mathematical literacy of about 78.7%. Because of this high pass rate in mathematical literacy, No improvements in matric maths (2009: 2 of 3) feels that many learners will choose to study mathematical literacy as a simpler alternative to mathematics, as a result "…this appeared to defeat the intended outcome of producing more potential in South African students to follow careers in mathematics-based disciplines".

The data base of the Free State Education Department (FSDoE) in 2006, showed that in mathematics HG the pass rate was 70%. Males with A symbols accounted for 5.3%, while female learners accounted for 4.5%. In mathematics SG the pass rate was 51.2%. Males accounted for 2.3% of A symbols, while females accounted for 1.4% of A symbols. For physical science SG the pass rate was 50.7%. Males with A symbols accounted for 2.3%, while females with A symbols accounted for 1.8%. For physical science SG the pass rate was 57.7%. Males with A symbols accounted for 0.1%, while female with A symbols accounted for 0.05% of the total group. These statistics clearly depict that males are still performing better than females in these subjects (RSA FSDoE 2006).

Concerning HE institutions, at the Vaal University of Technology 21% of students who enrolled for the engineering undergraduate degree in 2000 (Sutherland & Joubert 2004: 19) were females. Research indicates that South Africa experienced a remarkable improvement in the participation of women in the SET workforce between 1992 and 2001 (RSA DST 2004: 21), although some inequities still continue. Liebenberg (2002: 3) notes that South Africa produces about 1800 engineering graduates every year, of which only 8% are women, and only 238 women, register as professional engineers compared to 15 534 males. The Department of Science and Technology, RSA DST (2004: 12) maintains that women are still under-represented in the natural sciences and engineering; specifically engineering.

Statistics (RSA DST 2004: 27) reveal that in 2001, 61% (3370 out of 5514) of women instruction staff were concentrated in the social sciences and humanities as compared to 50% (3970 out of 7938) of men. In the natural sciences and engineering, 38% (3020) were men and 21% (1154) were women. When looking at natural science and engineering female instruction, women were mostly represented in the computer sciences and badly represented in engineering. In 2001 nine percent (75 out of 831) of women were instruction staff and 14% (33 out of 230) were research staff, and the senior academic ranks were dominated by men, where 26% were professors as opposed to only 7% who were women. In terms of publication outputs, the Centre for Research on Science and Technology (CREST 2005: 9) reports that women produce very few SET publications as opposed to men. It is also documented that in the 1990s women were responsible for only one fifth of publications in SET fields of study.

An Information and Communication Technology (ICT) audit conducted in 2005 revealed that although 55% of women ICT workers held Higher Education and Training (HET) qualifications, the minority of women, in contrast to men, were employed as ICT managers, engineers, programmers, technicians and artisans. A majority of women, however, is concentrated in technical sales and system analyst professions (James 2006: 47 of 75).

On the whole, the SET fields of study and careers seem to be still dominated by men in South Africa. Gender disparities are still noticeable because more men than women are found to occupy higher positions in the SET sector.

2.2.6 Interest and/or performance in SET of males and females in the rest of the world

Literature reveals that the issue of under-representation of women in general in science, engineering and technology (SET) is a worldwide problem (Sutherland & Joubert 2004: 19; Engle 2003: 5). In African higher education institutions, gender disparities are still observed between Black males and females, especially in the sciences. In Kenya (Teferra & Altbach 2004: 36) only 10% of females are enrolled in engineering and technology programs in public universities and in the natural sciences very low numbers of females are documented to be within public HE, and in Mauritius males are seen to dominate the Engineering Faculty. In Nigeria, Osiruemu (2007: 104) further contends that a large number of women are still found in teaching, catering, law and nursing, while in professions such as engineering and architecture the percentage of women is low in comparison to that of men. Assie-Lumumba (2006: 19) declares that higher education persists to be clearly dominated by males, more especially in science, technology and management. Assie-Lumumba (2006: 19) further indicates that in Nigeria women academic staff in the sciences accounted for 12.8% between 1996 and 1997. Those who enrolled for the sciences were at about 31.7%. Citing research done by Effah (2003), Assie-Lumumba (2006: 19) states that in Ghana, female enrolments increased from 21% to only 26% between 1991 and 1992.

The Science and Technology policy for Malawi confirms that 52% of the population in Malawi consists of women but not many are inspired to pursue science and technology studies (Gomile-Chidyaonga 2003: 2). Statistics between 1999 and 2003 indicate that there were some improvements in the enrolments of women in SET related disciplines. From 1999 to 2002 the enrolment of women in civil engineering increased from 7% to 9%; electrical engineering increased from 13% to 15% and in mechanical engineering no female enrolments were documented. For a degree in Architecture female enrolments dropped from 33% in 2000 to 31% in 2003. Female enrolments in the Environmental Health program increased from 9% to 27%, while 50% of women enrolled for Information Technology, Business Information Systems and Laboratory Technology Diplomas. An increase from 8% to 39% was documented for the Bachelor of Technical Education degree between 1999 and 2003 (Gomile-Chidyaonga 2003: 2).

Kennedy and Parks (2000: 533); Gray (2005: 6 of 16); Brownlow, Jacobi and Rogers (2000: 120), confirm that the performance of males and females in mathematics and science is not significantly different, but by the end of the secondary school gender differences are evident in American schools. In this regard Halpern, Aronson, Reimer, Simpkins, Star and Wentzel (2007: 6) mention that girls seem to doubt their capability in mathematics and science. Sullivan (2006) argues that, although young women dominate as US secondary school graduates, they are still less visible in the engineering pipeline. Females account for only 20% of new B.S. Engineering enrolments. Interestingly enough, citing research done by Brandon (1991), Yu and Sandra (2008: 7 of 20) document that "…Asian American women had as high a percentage of women in engineering majors (9%) as male students of any other group". Yu and Sandra (2008: 6 of 20) further mention that both Asian American women and men are highly represented in SET as researched by Suzuki (1998) and the NSF (2004). Referring to studies conducted by the NSF (2004), Yu and Sandra (2008: 2 of 20) confirm that the rate at which Asian Americans earn science and engineering bachelors' degrees is increasing when compared to the rate of White students. Hence Asian Americans are labelled as the 'model minority' (Yu & Sandra 2008: 2 of 20).

In the more industrialised countries, CREST (2005: 14) suggests that there have been dramatic improvements in female enrolments for higher education degrees in South Africa, but women are still under-represented in SET. Moletsane and Reddy (2008: 8-9) note that, in the United Kingdom, out of 44% of Masters degrees and 37% of PhDs awarded in SET, women only make up a quarter of the workforce. In most European countries women are less represented in engineering with 6.4% women in Denmark, 2% in Ireland and 5% in France.

Statistics provided by Women in Science and Engineering (WISE) (in Sutherland & Joubert 2004: 19) reveal that only 20% of women in Canada and 17% of women in America have enrolled in undergraduate engineering fields of study over the past few years. In the USA women make up 8.5% of engineers, in Japan 2.9% and in France 22% (Liebenberg 2002: 3). In Sweden the number of females in the engineering bachelor's program is at 26%, which, according to Gustafsson (2000: 21), is a fairly high percentage against an international setting.

In Britain studies conducted by Ochugboju (2000: 12) document that women comprise less than 15% of the science and engineering professional and technical labour force. In information technology and engineering, representation is extremely low, while in skilled engineering trades 2.5% of the workforce is made up of women. Ochugboju (2000: 12) further indicates that in all SET sectors women are found to be less represented, especially at senior levels and the rate at which women progress in their careers is slower than that of males.

CREST (2005: 14) further documents that in the United Kingdom very few women enrol for physical science, mathematics and computer sciences at undergraduate level and the situation becomes even worse at post graduate level. In Europe, although numbers of females obtaining degrees in SET fields are increasing, they are still grossly under-represented in higher scientific positions, and furthermore, very few women occupy senior positions in the SET workforce.

In teacher training programmes in California, a study conducted by Swan (1999: 4 of 34) found that most of the female candidates were enrolled to study teaching in primary schools. In secondary schools male and female teacher enrolments were more or less equal with a higher percentage of males enrolling to teach mathematics, science and technology.

Coulter (1999: 118) confirms that, in Canada, despite a number of programmes funded by government and the private sector to increase girls' enrolments in science and mathematics, women have persisted in their reluctance to study these subjects in secondary schools when these subjects become optional. In addition, women fail to increase enrolments in engineering and applied sciences at tertiary institutions. Interestingly, a survey conducted by the Foundation for Research Development in partnership with the Human Sciences Research Council (HSRC) in 1995, showed that out of 20 nations, Canada was the best performing country in scientific and technological literacy [(Department of Arts, Culture, Science and Technology) (RSA DACST 1998: 5)]. It is, however, surprising to find that women in Canada avoid studying in the SET fields.

Lessons in Learning (2007: 2-3 of 9) reveals that in 2001 15% of women in Canada had a university degree and outnumbered men in most post-secondary fields of study. But women still persist in being under-represented in SET fields of study. In 2006 women comprised 47% of the workforce in Canada, but the percentage of women in professional, scientific and technical services had dropped in relation to the proportion of women in the labour force.

The under-representation of women in science is addressed in many countries, such as the United Kingdom, Canada and the United States (CREST 2005:12). These countries have compiled information on the status of women in SET in order to address this problem. Citing McGregor & Bazi (2001), CREST (2005: 13), documents that there are a number of initiatives for women in SET internationally which aim at improving the representation of women in SET fields of study and careers.

This literature review suggests that women in general are under-represented in SET globally. Males and females appear to perform equally well in mathematics and science at school but females lose interest in these subjects by the end of their secondary school years. On the contrary, Asian American women are found to be highly represented in the SET and consistently pursue SET fields of study and careers. Educational institutions and planners are confronted with challenges of diagnosing these problems and coming up with solutions to change this situation in order to attract, increase and sustain female enrolments in the SET fields of study.

2.2.7 Interest and/or performance in SET of Black females and Black males in South Africa

When one examines the interest or performance in SET of Black females in South Africa the picture for such women in particular becomes more gloomy. The Edusource Data News (2003: 24) documents that the 2002 grade 12 results in South Africa for physical science and mathematics HG revealed that the performance of Black females was poorer than that of their Black male counterparts. The percentage of passes for physical science HG was 26.6 % for males and 19.9 % for female, and for mathematics HG it was 31.1% for Black males and 22.8% for Black females.

In a study conducted by Maree et al. (2006: 231-237) in May 2002, in Mpumalanga secondary schools with grade 8 and 9 learners, learners had to complete tests which required a basic understanding of science and mathematics processes relevant to the grade 8 and 9 level. The overall results revealed that students in general did not perform well in the science and mathematics tests. Regarding contrasting results for Black males' and Black females' achievements in the science and mathematics tests, as documented by the Edusource Data News(2003: 24) above, Maree et al. (2006: 231- 237), report that there were no major differences between the achievements of Black male and Black female grade 8 and 9 learners in the science and mathematics results.

These contrasting results reported by Maree et al (2006: 231-237) confirm studies undertaken by Kennedy and Parks (2000: 533); Gray (2005: 6 of 16) and Brownlow et al. (2000: 120), which indicate that the performance of males and females in mathematics and science is not significantly different in early secondary school years but becomes significantly different by the end of secondary school.

To analyse the performance of Black learners in science and mathematics in South Africa, Kahn (2004: 150) used the language proxy method to track Black learners' achievement in these subjects between 1999 and 2002, with the assumption that the studying of a Black language could be a good indication for being Black. Kahn (2004: 149) indicates that this was the only method he could use to determine the performance of Black learners in mathematics and science because there were no reliable data before the move to democracy. Furthermore, it was policy not to gather racially disaggregated data between 1994 and 2001. Kahn (2004: 150) confirms that although this method was not 100% accurate it gave an indication of the status of Black learners in mathematics and science because the education system of the past forbade efforts to examine the performance of Blacks in these subjects. The Language Proxy method revealed the following results, (Kahn 2004: 151-154):

Table 2: Language Proxy group with male: female pass rate by province for 2002

Province	Mathematics Higher Grade		Mathematics Standard Grade		Physical Science Higher Grade		Physical Science Standard Grade	
	Male %	Female %	Male %	Female %	Male %	Female %	Male %	Female %
Western Cape	69.4	54.1	46.7	33.3	65.3	54.7	61.2	50.3
Northern	61.1	30.0	75.2	55.1	73.7	66.7	79.0	71.2

Cape								
Free State	54.1	41.3	52.2	37.0	33.2	18.5	57.0	46.3
Eastern Cape	41.9	33.8	41.3	29.7	42.0	28.4	48.0	39.6
KwaZulu Natal	21.6	12.4	37.1	27.1	25.1	20.0	57.1	52.1
Mpumalanga	29.8	11.4	34.5	20.6	21.2	10.4	41.0	32.3
Limpopo	23.2	10.8	41.0	28.4	22.6	13.6	53.7	47.1
Gauteng	32.9	29.8	43.4	29.6	29.1	25.4	55.1	47.2
North West	46.4	35.5	38.6	28.6	32.7	22.5	50.0	43.2

Source: Internal data of the Department of Education (Kahn 2004: 151-154).

When the language proxy method was used to compare Black male and Black female pass rates by province in 2002, it was found that Black males performed better than Black females in all subjects across provinces. When the performance of Black males and females who do not take a home language as an examination subject was compared, it was found that there were no consistent gender differences between males' and females' performance in mathematics and science. Black females performed better in five of the nine provinces. However, there was a difference between the performance of Black males and females who take their home language as an examination subject. Kahn (2004: 154) believes that the explanation for the dissimilar performance between Black males and females who do not take their home language as an examination subject and Black males and females who take their home language as an examination subject, was that the non-mother tongue group was exposed to a different type of school, either an independent or a former Model C school. When one examines the pass rates, as portrayed by the proxy method, the picture is not good for Black females.

The Facing the Facts study (RSA DST 2004: 13) indicates that, although Blacks in general are under-represented in SET fields of study and careers, Black men are still found to be more represented at the SET doctoral enrolments and graduations than Black females. In 2001 Doctoral enrolments and graduations for Black males and females were at 31% and 21%; and 25% and 15%, respectively.

In summary, not much research has been done on the performance and pass rates of Black females in particular in SET programs and fields of study in South Africa, but the available research indicates that Black females, particularly those who attend school at historically Black schools, do not perform as well as their Black female counterparts who attend former Model C schools. In 'Black' schools, Black males appear to perform better in mathematics and science than Black females do. If the type of school has an influence in the performance of learners in mathematics and science then the majority of Black females in South Africa will most probably not be able to feature in the SET fields of study and careers, because most of them still attend 'Black' schools.

2.2.8 Interest and/or performance in SET of Black females and females of other races in South Africa

When a comparison is drawn between the position of Black women and women of other races in South Africa, literature reveals that, although the data supplied by the RSA DoE (2003-2006) reported a decrease in the gender gap participation and pass rates in mathematics and physical science at school level between males and females in general, the situation has not changed for Black females. The Edusource Data News (2003: 23) showed that in the 2002 matric results in South Africa, White and Indian females performed better in physical science HG, with pass rates of 87.7% and 75.4% respectively, while Black females' pass rate was only 19.9%. In mathematics HG in the same year, White and Indian females' pass rates were 88.9% and 72.3% respectively, while Black females' pass rate was 22.8%.

When one examines doctoral enrolments and graduations by race in 2001, White women accounted for 65% of all female doctoral enrolments and 76% of all female doctoral graduates. Black females accounted for a mere 21% of doctoral enrolments and 15% of doctoral graduates (RSA DST 2004: 28). Furthermore, in the same year it was found that

White females represent about 70% of academic staff in higher education. Black, Coloured and Asian females account for 33% of the Reconstruction and Development (R&D) personnel.

While there is increasing opportunity and access to formal education, Brown (2006: 1 of 6) specifies that Black women are still "…under-represented, under-employed and under-valued". Black women seem to have lower levels of education than all other groups. This research indicates that, in 2004, grade 12 results showed that low numbers of Black candidates passed mathematics and physical science at HG and numbers were even worse for Black females. Citing research done by the Community Agency for Social Inquiry (CASE), Brown (2006: 2 of 2) confirms that Black women graduates increase by about 8% per year but they are still insufficiently represented in SET. The study conducted by Women in Science (2003-2007: 1) showed that, at doctoral levels, Black women are under-represented in the natural sciences and engineering, as well as in the social sciences and humanities.

When commenting on the present situation of Blacks in general in South Africa, at a symposium organised by the South African Agency for Science and Technology Advancement (SAASTA) (2008), Professor Cheryl De La Rey said, "… We were very disappointed to find that Black women in particular

were not represented in many SET careers, such as in electrical engineering. This is a concern and it is something that we should look at with partners in higher learning institutions and the private sector". James (2006: 65 of 75), however, argues that there is not much research muscle in the country on SET and ICT research and as such it becomes difficult to build up sensible strategies to increase the number of women in the SET and the ICT sector.

In conclusion, it appears that Black women do not perform as well in the SET fields of study as do women of other races in South Africa from as early as the secondary schools years. This might be the reason why the position of Black women in the SET fields of study in HE institutions and careers in South Africa is discouraging.

2.2.9 Interest and/or performance in SET of females of different race groups in the rest of the world

While research suggests that women of all races are under-represented in the SET fields and careers, the situation of African American females in the USA is also discouraging (Loya 2000: 29). Although a literature study that has been undertaken, strongly argues that women in general are under-represented in SET fields of study and work places, statistical data are lacking as far as Black women in particular are concerned, internationally. Bebbington (2002: 362) argues that in most European countries ethnicity data are absent and this makes it difficult to monitor the involvement of ethnic minority women in SET. Furthermore, Bebbington (2002: 371) complains of a tendency to regard women as a solitary, integrated group when statistical analyses are carried out in scientific employment whereby data disaggregated by ethnicity are not often presented. The reason given is that the numbers are too small. As such the problem of the under-representation of women in general in SET "… cannot be quantified and tackled". Gatta and Trigg (2001: 24-26) confirm that minority groups, particularly African Americans, do not perform well in mathematics and science at secondary school level and are still lagging behind in obtaining bachelor's degrees in SET.

Despite increasing enrolments of women in tertiary institutions, women have seemingly continued to be under-represented in SET fields in secondary schools, higher education institutions and the workplace, internationally. This matter has been under discussion especially in Australia (Goodell1998: 1 of 6), the United Kingdom (Bebbington 2002: 360), the United States (Kuh 2001: 44 of 96), Canada (Coulter 1999: 118) and Africa (Teferra & Altbach 2004: 36). In addition, the matter has been receiving attention internationally in organisations such as the United Nations and the European Commission (RSA DST: 2004: 22).

Bebbington (2002: 361) highlights the fact that in the USA African-Carribean women are under-represented as science students from school through higher education hence their under-representation in scientific employment, despite their numbers in the general population. Gatta and Trigg (2001: 25) comment that in the USA the majority of White and Asian females enrol in Advanced Placement Science and Mathematics courses. These courses provide students with opportunities to gain college credits for secondary school work and aid them in enrolling at the best colleges. By contrast it was found that Latinos and African American females have about half the enrolments when compared to White and Asian females. Loya (2000: 30) accentuates that in 1997 African American, Hispanic and American Indian women were markedly under-represented in SET at colleges when compared to White women, while Asian women were well represented. Research done by Yu and Sandra (2008: 6 of 20) confirm that Asian American women perform better in SET than White American women. In the New York region's Westinghouse Science Talent Search, which took place between 1975 and 1983, among Asian Americans who won the Talent Search half were women and only a quarter of the winners were White American women.

There are indications that African American females are under-represented in respect of science and engineering degrees at all levels. Loya (2000: 36) states that for both males and females, African American recipients of Masters' degrees in SET in 1998 were at about 2.5%. The National academy of Sciences (2006: 3) also found that women from minority racial and ethnic groups are grossly under-represented if not absent from SET senior ranks. In Pakistan, Bangaldesh and Black Carribean Countries, females who want to pursue their studies, especially in SET fields, are hampered by inadequate preparation that would have assisted them in making informed choices (Osiruemu 2007: 103-104).

Fancsali (n.d) indicates that in 1997 5% of all scientists and engineers in the labour force were women, Blacks accounted for 1%, Hispanic women for 1%, American Indian women for 0.1% , and Asian women accounted for 2%.

In conclusion, it can be said that ethnic females appear to be grossly under-represented in SET fields of study and careers. Ethnic females seem to receive a poorer education in SET than their White counterparts do at school level. This prohibits them from pursuing scientific fields of study at HE institutions. As a result they will most probably continue to be less represented in the SET fields of study. As a result of this measures are certainly needed to counteract female under-representation in SET, with a special focus on Black females.

2.3 Policies and guidelines to increase enrolments in SET in South Africa

In responding to problems of under-representation of women in SET, and in attempting to increase and diversify women's participation in SET, there are policies and guidelines the South African government has put in place. CREST (2005: 9-10) documents amongst others, two policy areas mainly related to studies of women in science and technology, and higher education. These policy documents and strategies incorporate the White Paper on Science and Technology and its related National Reconstruction and Development (R&D) Strategy; and the White Paper on Higher Education and its interrelated National Plan for Higher Education. The R&D strategy is aimed at identifying ways of increasing the human resource foundation in connection with women and Blacks. The National Plan, on the other hand, focuses on human resource issues from the supply side.

CREST (2005: 9) documents that the R&D strategy found that Black and female scientists, engineers and technologists do not enter "…the academic publishing ranks and that the key research infrastructure is composed of people who will soon retire". The White Paper on higher education brought to light a series of flaws and major challenges in the higher education system. One of the challenges was found to be an unfair distribution of right of entry and possibilities for students and staff along racial lines, gender, class and geographical setting, and a lack of substantially qualified graduates in SET and commerce, due to the limited access of Black and female students, because of biased education systems of the past. The National Plan indicated that, although gender equity has been attained in universities, it is still a drawback in universities of technology (technikons). Moreover, female students in general are still concentrated in humanities and are poorly represented in SET and in post graduate programs, in academic and professional ranks, and especially at senior levels. The situation is worse for Black people in particular.

To remedy the situation the new integrated science curriculum was developed. In the General Education and Training Band (GET) natural sciences, technology and mathematics are compulsory while in the Further Education and Training Band (FET) mathematical literacy and mathematics are compulsory (RSA DST 2006: 10) (as indicated in 2.1 above). The Strategy to increase enrolments in SET was to use Olympiads, Competitions and Camps to discover and support learners, especially Black and girl learners with ability and potential. The aim is to increase the number of learners doing well in mathematics and science HG, with special emphasis on schools from disadvantaged backgrounds (RSA DST 2006: 13). The following Olympiads and Competitions were established:

- Eskom Expo for Young Scientists
- UCT Maths Competition
- Minteq Minquiz
- Pan African Mathematics Olympiad
- South African Mathematics Olympiad
- Interprovincial Mathematics Olympiad
- ISPAT ISCOR National Science Olympiad
- National Natural Science and Biology Olympiads

A SWOT analysis of the data collected from 5 of the 8 Olympiads and Competitions, by the DST, revealed that the participation of girls is low and those that do take part do not do so as keenly as boys do. It has also been noted that the number of Blacks participating in these Olympiads and Competitions is still low and their performance is still poor (RSA DST 2006: 13).

The main initiative of the Department of Education (DoE) is the Dinaledi Project. The project was initially aimed at improving the performance of Black learners and former Black schools rather than White, Coloured and Asian schools in mathematics and science HG, although at a later stage some former White schools in Gauteng, the Western Cape and KwaZulu Natal were included (Bernstein 2007: 11). Bernstein (2007: 11) confirms that the effect of the Dinaledi project is difficult to determine and the analysis of the project shows that most of the HG mathematics and science passes are obtained by a few high performing schools and that in most schools performance has not changed, while in some schools it has actually declined. Furthermore, it was found that the initiatives to increase participation in mathematics and science at national, regional and local levels sponsored by private companies have little lasting impact on the quality of mathematics and science in schools. Bernstein (2007: 12) indicates that these private companies have to relocate their efforts on changes in the system that can have desirable effects on the quality of mathematics and science in the schooling system, and that the Dinaledi project has also not yet achieved its goals.

The DST negotiated a bilateral research programme with foreign partners and the National Research Foundation (NRF) in 1996. This programme of scientific interactions between the United Kingdom (UK) and South Africa aimed at supporting historically deprived universities in order to develop skills and excellence in certain areas of science, engineering and technology (Lickindorf 2005: 392). Its objectives were to:

- *"Increase the number and quality of Black researchers and lecturers in science, engineering and technology in South African universities;*
- *Improve access of Black staff in the South African higher education sector to UK research and research institutions;*
- *Establish centres of excellence in historically disadvantaged universities through the assistance of UK experts;* and
- *Encourage collaborative research projects between centres of excellence in Britain and South Africa"* (Lickindorf 2005: 392).

Lickindorf (2005: 392) mentions that the bilateral projects still benefit White male researchers from historically White universities and that "race groups" with relatively low numbers of researchers are not even aware of opportunities provided by these bilateral programs.

Although there are increasing opportunities and access "…choice of field of study and lower levels of progression into postgraduate level place Black women at a disadvantage when seeking employment. Enrolment into certain fields, remains predominantly White and male, especially engineering, sciences and technology" (Brown 2006: 2 of 6).

Researchers attribute this under-representation of women and Black women in particular, in SET, to a number of factors such as aptitude for a specific vocation, interest in SET, socio-economic factors, socialisation practices, occupational sex-role stereotypes, lack of self confidence, lack of female role models, lack of vocational guidance in secondary schools, under qualified mathematics and science educators, parental support for a certain career, practical barriers and attitudes towards different vocations .

2.4 Conclusion

In this chapter, it has been attempted to determine whether the representation and performance of Black women in SET in South Africa are similar to or different from that of Black women in other countries; how the representation and performance of Black women in SET in South Africa compare with the position of Black men in the country; and finally, how the position of Black women in SET compare with the position of White women in South Africa and worldwide.

In response to these questions it can be concluded that the position of Black women in South Africa is very similar to the position of Black women in other countries because Black women globally seem to be insufficiently represented in SET fields of study and careers. Furthermore, in South Africa although Black men are seemingly still under-represented in SET, Black women are still the worst represented in these fields. Lastly when the position of Black women is compared to that of White women in South Africa, it is found that White women are better represented in SET than Black women are.

There are therefore indications that Black women in general, on a worldwide scale and in South Africa, are grossly under-represented and perform poorly in SET. Even though Black women are increasing their enrolments at HE institutions in South Africa, the proportion of Black women obtaining degrees in SET is far less than that of White women and Black men. Those exceptionally few who manage to obtain degrees in SET do not occupy senior positions as their male counterparts do, and are unlikely to reach the highest scientific hierarchy.

Given the population statistics of Blacks in general in South Africa, it is evident that the scarcity of skills in the SET sector will most probably not be addressed adequately if Black women in particular are less engaged in these fields.

In searching for the answers as to why Black women do not sufficiently engage in SET fields of study we need to investigate all likely factors that might influence the career choices of young Black women. These factors will be discussed in the next chapter

CHAPTER 3

FACTORS THAT MIGHT INFLUENCE VOCATIONAL CHOICE OF BLACK WOMEN

3.1 Introduction

A number of studies have attempted to explore and explain the factors that might influence the entry and development of women in science. Research studies in developing countries globally identify a variety of factors that might inhibit women in general in choosing a career in science. Bloye (2007: 10 of 111) classifies these factors into two categories, namely cognitive and non-cognitive factors. Bloye (2007: 10 of 111) confirms that while much international research has been undertaken on these factors which might affect career choices of students, there seems to be few empirical studies within the South African context. De La Rey (2007: 2 of 5) attests that these factors "… make it more challenging for women to succeed in scientific careers".

In South Africa the prevailing attitude towards women and Blacks in science has changed dramatically since the new democratic government has been elected. The changed attitude has resulted in the government initiating policies and guidelines which aim at increasing and diversifying Blacks and women's participation in SET (as discussed in chapter 2). Therefore the focus of this study is to investigate the attitudes and sex-role stereotypes regarding careers in SET, of Black women and to determine whether Black women's attitudes and occupational sex-role stereotypes towards these fields have changed in response to the policies and guidelines regarding SET, which is to increase enrolments into the field at school and university levels.

This chapter focuses on both cognitive and non-cognitive factors regarding decisions for the choice of a career. Aptitude for a specific vocation is a cognitive factor, while non-cognitive factors include interest in a particular subject, parental support, lack of self confidence, practical barriers, distance from the university and attitudes towards different vocations.

3.2 Aptitude for a specific vocation

Citing Corno et al. 2002, Lohman (2005: 337) contends that aptitude is "…the degree of readiness to learn and to perform well in a particular situation or domain". In addition, Lohman (2005: 336) refers to aptitude as something that is not fixed at birth and that individual achievements help form aptitudes. As such, aptitude entails more than cognitive structures such as ability or accomplishments. He further argues that aptitude does not refer to personal attributes independent of the environment but is linked to context.

Research done by a number of researchers such as Rebhorn and Miles (1999: 316); Joyce (1999: 261); Kennedy and Parks (2000: 533) citing studies conducted by Leslie, McClure and Oaxa in their 1998 article; Halpern, Aronson, Reimer, Simpkins, Star and Wentzel (2007: 27) and Fancsali (n.d.:1), confirm that in the USA boys and girls perform equally well in primary school mathematics and science, display confidence and interest in similar ways. These researchers also confirm that interest and confidence in mathematics and science gradually diminishes by the end of secondary school. When students are exposed to the Scholastic Assessment Test (SAT) used when selecting students for admission to colleges and universities, on the mathematics part of the SAT (SAT-M), males are found to perform better than females.

In addition, Spelke (in Musings 2008: 3 of 10) reiterates that men and women are equal in mathematics and science aptitude, and that the resulting equal performance proves that mathematical and scientific reasoning has a biological base found in both males and females. Rebhorn and Miles (1999: 317) argue that if gender differences in mathematics achievement develop during secondary school years, then the environment might be one of the factors contributing to girls' under-representation in science related fields. Citing studies conducted by Paulos (1995), Rebhorn & Miles (1999: 316) believe that the SAT does not measure all dimensions of scholastic ability. These researchers found that when there are no time limits to the completion of the test, gender differences are minimised. It was also found that there are questions in which males constantly do better than girls. It is, however, not clear how these test items affect girls' scores. Rebhorn and Miles (1999: 316) state that these test items are disadvantaging girls' scores in the SAT-M.

Stephen, Welman and Jordaan (2004: 42) state that the use of matriculation symbols seems to be a contentious subject, with numerous researchers providing different results. Regarding this matter Pocock (2004: 13) indicates that "… what matriculation scores tell us is open to debate". Citing research done by Welman (2000), Stephen et al. (2004: 43) indicate that given the historical educational background of Black students in South Africa, matriculation results are not consistent predictors of aptitude for Black students and it is recommended that for them matriculation results cannot be regarded as a true reflection of academic ability. Sadler and Erasmus (2005: 33) also believe that matriculation results cannot predict factors which influence academic success at higher education institutions.

Students' success or failure at higher education institutions has been a bone of contention among many academics (Sadler & Erasmus 2005: 32). These researchers question the effectiveness of selection methods such as matriculation results and SATs which are normally used as selection criteria for entry to universities. They believe that these selection criteria lack empirical support. Sadler and Erasmus (2005: 33), citing studies conducted by Schmelzer, Schmelzer, Figler and Brozo (1987) and Killen (1994), state that the most important factors affecting academic success at higher education institutions could, amongst others, be students' interest in the course and motivation. Sadler and Erasmus (2005: 33) feel that factors such as interest in the course, motivation, self-discipline and effort …"cannot be predicted from matriculation results". Citing studies conducted by Reynolds and Walberg in 1992 and Singh et al. (2002), Tuan, Chin and Shieh (2005: 648) state that students' attitudes and motivation are significant factors in predicting students' success in science while students' motivation is the most crucial aspect in predicting students' attitudes towards science.

In summary, research has shown that aptitude does not play a determining role in the choice of a career but that there are other factors that are not identified yet, that might inhibit women from enrolling in great numbers in SET. While boys and girls perform equally well in science and mathematics at the primary school level and early secondary school years, girls seem to lose interest along the way, especially during their secondary school years.

3.3 Interest in Science, Engineering and Technology

Countryman, Kekelis and Wei (2006: 3) indicate that girls usually seem to lack interest in the SET fields despite the fact that they want to make the world a better place. They do not see how their interests fit in with science, engineering and technology. They prefer to major in social/biological or agricultural science (Slashinski 2004: 2). The same sentiments are shared by Sharf (1997) (in Foster 2005: 9) where it is indicated that interest inventories show that women in general are more interested in arts, clerical and social occupations than men, and display lack of interest in scientific and technological occupations.

Plug, Louw and Meyer, (in Maree & Beck 2004: 80), state that career counselling is a combination of all counselling processes associated with the choice and preparations for a career in the form of interviews, interest questionnaires, aptitude tests and personality tests. Maree and Molepo (2007) found that assistance in career counselling was lacking in many South African schools and as such many learners in Black schools did not receive adequate career counselling. Career guidance opportunities were offered at White schools (Du Toit 2005: 6). Geldenhuys and De Lange (2007: 129) cite Botha and Ackerman (1997) when indicating that lack of guidance in choosing school subjects has been a barrier in the sense that Black adolescents in South Africa are seemingly not capable of making informed career decisions. In addition, career counselling in South Africa is still expensive and can only be accessed by people who can afford it, while poor communities are further disadvantaged (Maree & Beck 2004: 8; Maree & Molepo 2007).

It has been documented that the traditional methods of career counselling do not provide adequate results in respect of different populations in the South African context because they have been widely applied in regard to White South Africans only. Because these traditional methods of counselling are still based on Western principles they are not necessarily legitimate and trustworthy for use among the diverse South African cultures (Maree & Molepo 2007; Maree & Beck 2004: 81).

Ebersöhn and Mbetse (2003: 324) state that the present structure of career education is complicated. In South African schools career education is addressed in the Life Orientation learning area. These researchers assert that educators in the Limpopo rural community expressed their lack of skills in offering career education to learners (Maree & Molepo: 2007) and in engaging with career counselling matters. Another disturbing issue (Ebersöhn & Mbetse 2003: 324) is the tendency of schools to allocate Life Orientation to any educator in order to fill gaps in the timetable and this further derails career education.

Vocational interest inventories have been found to be gender biased (Foster 2005: 43; O'Malley & Richardson 1985: 295). Foster (2005: 43) substantiates that aptitude tests are different in norm scores. Scores given to spatial visualization for males and females were found to be different. Citing studies by Sharf 1997, Foster (2005: 43) verifies that although improvements have been made to these inventories, they still only reaffirm societal stereotypes.

O'Malley and Richardson (1985: 298) conducted studies with 249 counsellors in the USA and in Canada. Their results also showed that counsellors hold stereotypical beliefs about men and women. These researchers believe that career counselling can yield negative results to clients if counsellors are found to favour societal role stereotypes and that the selection of therapeutic ideas and procedures can be affected by the counsellors' expectations and perceptions of what clients desire.

Chae (2002: 147) cites earlier research conducted by Broverman, Broverman, Clarkson, Rosenkrantz and Vogel in 1979, who found that counsellors set double standards for women. More socially popular qualities were credited to "healthy men" than to "healthy women". Furthermore Chae (2002: 147), referring to studies conducted by Herr and Craimer (1992) and Worrell (1980), found that counsellors displayed negative attitudes towards women pursuing non-traditional careers requiring mathematics or science experience. Citing studies conducted by Donahue and Costar (1977), Chae (2002: 147) documents that secondary school counsellors had a tendency of recommending lower paid jobs which are highly supervised and required minimal education for girls. These recommendations were not applicable to boys.

In short, research results on interest inventories indicate that interest inventories can yield positive and/or negative effects regarding career choices of girls depending on the person administering these tests. Due to lack of career guidance in Black schools in South Africa, Black students seem not to be exposed to different careers from which they may choose, as their White student counterparts are. Even though career counselling services are now available they are still expensive and this further prohibits Black students in general from accessing such services.

3.4 Parental support for a certain career

In this section two aspects related to parental support for a certain career are discussed, firstly parents as role models and secondly, parental support and encouragement.

3.4.1 Parents as role models

The level of education of the parents plays an important role in the career aspirations of adolescents, according to Mortimer, Dennehy and Lee (1982) (in Besecke & Reilly 2006: 4 of 17). Citing research conducted by Lemkau (1983), Besecke and Reilly (2005: 4 of 17) indicate that women in non-traditional occupations have more regularly encountered family environments which are enhanced by different models in which they were motivated to explore an unusually wide range of behaviours and career options. These women were more likely to state the positive influence of men or fathers and male teachers, while women following traditional careers would recount more female influences.

In addition, Kracke (1997), (in Foster 2005: 43), confirms that parents who promote children's independent thinking and exploration of careers tend to develop children who are more capable of exploring careers than the children of parents who do not encourage independent thinking. The same findings have been reported in an American survey of women engineers and those still studying at university. The majority of women engineers or those studying engineering reported having a close family member who is an engineer (Liebenberg 2002: 4; Monhardt et al. 1999: 536).

Bandura, Barbaranelli, Caprara, and Pastorelli (2001: 189) contend that much research has been conducted on the influence parents have on their children's academic achievements, but that little research has been done on how parental influence affects career developments of children. Bandura et al. (2001: 189) believe that parents with high academic efficacy instil the desire for scholastic success and accomplishment in their children. Bandura et al. (2001: 189) claim that such parents would generally discourage children from following careers "… relying heavily on manual labour or routinized service".

Ferry (2006: 4 of 6) indicates that in rural Pennsylvania it was found that, in affluent secondary schools learners seem to have more family and school support in career exploration and family members provided valuable learning experiences by becoming role models for their children.

3.4.2 Parental support and encouragement

Parents' actions can have a negative (unintentionally) or positive influence on their children's career development, and this influence is significantly strong with respect to mothers (Lessons in Learning 2007: 4 of 9). Furthermore, parents of daughters tend to believe that their child lacks interest in science or that science is more unmanageable for their daughters than for their sons. A study conducted by Foster (2005: 62) at an FET college in South Africa revealed that Black female engineering students have family members who encouraged them to follow engineering studies.

Research studies conducted by Heystek and Louw (1999) and Myeko (2000), cited by Louw (n.d.), indicated that many South African parents, especially in disadvantaged communities and rural schools, are not adequately involved in their children's learning. In a study conducted in Bloemfontein's disadvantaged schools, Louw (n.d.) found that there is a lack of parental involvement in their children's learning. Parents were found to have negative attitudes towards schools and in some cases parents reported lack of education. According to Bandura et al. (2001: 198), "… aspiring parents act in ways that build their children's academic, social, and self-regulatory efficacy, raise their aspirations, and promote their scholastic achievement". Another discouraging factor according to Liebenberg (2002: 4) is that girls do not discuss science and technology issues with their parents as much as boys do.

Parents can have a negative influence concerning careers their children want to follow. In a study conducted at The Rand Afrikaanse University (RAU), a female engineering student indicated that her mother was not happy when she announced that she wanted to study engineering. The female engineering student expressed her fears that she would not be able to marry because people would regard her as weird (Liebenberg 2002: 4).

The literature study shows that parents could be powerful forces in helping and guiding children in choosing careers. It is also evident that the educational level of parents plays a vital role in the choice of their children's career. Those children (especially Black) who find themselves surrounded by uneducated parents and family members are usually disadvantaged because they lack strong parental influences and encouragement to pursue careers in SET.

3.5 Lack of self-confidence

Halpern et al. (2007: 6) found that, generally, girls and women do not have as much confidence in their mathematical abilities as males do and this usually leads to a decreasing interest in mathematics and science careers by early adolescence, even though males and females display similar abilities in these subjects. Halpern et al. (2007: 6) indicate that theory and empirical research suggest that beliefs about abilities are key factors in determining interest and performance in different subjects as well as career choices. Foster (2005: 41) believes that confidence plays a major role in achievement, even if one has the ability, and that lack of self-confidence contributes to underachievement. Foster (2005: 41) further purports that females' under-achievement and lack of persistent participation in science and mathematics, despite their being talented in these subjects, is because of low levels of self-efficacy.

Similarly, Moletsane and Reddy (2008: 16) confirm that women in SET have displayed low confidence and that the low self-confidence might be ascribed to fears of failure or being categorised as useless. Furthermore, Lui and Wilson (2001), (in Moletsane & Reddy 2008: 16), indicate that lack of self confidence is a barrier to self development in SET. Wasburn and Miller (2004: 157) believe that lack of self-confidence in women's abilities could be due to career goals which are not well defined and this in turn makes women view college and university classes as unfriendly to them, with the result that their learning is obstructed. Monhardt, Tillotson and Veronessi (1999: 534) contend that research conducted by the Center for the Education of Women at the University of Michigan indicates that women are not confident of their abilities in science and therefore need to be encouraged to pursue careers in science. Lessons in Learning (2007: 4 of 9) confirms that girls consider science to be a difficult subject and that a possible reason could be that during middle school years girls begin to lose confidence in their abilities to learn science even though their performance does not differ significantly from that of boys. Daramola, Van den Berg and Mudondo (2002: 13) confirm that because women lack self-confidence they are fearful of taking big risks by applying for a job if they cannot perform even a few functions required for the job.

In brief, lack of self-confidence can be a barrier for women in science achievement in general, and in choosing a career in science irrespective of being gifted in the science subjects or not. Unfortunately women in general are found to be more obsessed with lack of self-confidence than men.

3.6 Practical barriers

Three practical barriers are discussed in this section, namely socio-economic factors, family circumstances and distance from HE institutions.

3.6.1 Socio-economic factors

Moloi (n.d.: 4) argues that apart from commonly known cognitive challenges that learners in general have when confronted by mathematics learning in particular, in South Africa, the apartheid government offered insufficient educational resources for Black students. Lack of sufficient educational resources in Black schools is also confirmed by Mbanga (2004: 105). Similar findings are documented in Gardner (2000: 18) in that in historically Black American schools, insufficient funds to study in SET directions were allocated by the government.

Salie (2005: 23) states that grade 12 results provide evidence that Black learners who come from economically disadvantaged families and whose social and emotive desires are not met by the existing education system, are more prone to collapse than students coming from economically privileged families. In confirmation, Macgregor (2007: 1 of 4) reiterates that Black South Africans comprise the largest group (73%) of university students with low socio-economic status (SES) while this is true of only 12% of White university students.

Reeves and Muller (2005: 105), citing the studies conducted by Howie and Hughes (1998); Joint Education Trust (2000 & 2001); and Smith (2004), document that high levels of under-performance in schools within high poverty areas are evident. And in 2004 the Western Cape outcomes of the systemic Literacy and Numeracy tests for grade 6 learners depicted a fair relationship between achievement and poverty. In addition, another study conducted by Moloi (n.d.) concerning South Africa's participation in the Southern and Eastern Africa Consortium for Monitoring Educational Quality Study (SACMEQ11) Project, it was found that students with low socio-economic status (SES) achieved more poorly than those with high SES. Sixty-five percent of low SES learners achieved SACMEQ level 1 (pre-numeracy) and 2 (emergent numeracy) which is equivalent to grade 2, 3 and lower, respectively.

Women in Science (2003-2007) documents that, in South Africa, poor families may restrict girls' access to primary and secondary schools or girls might be forced to choose less expensive subjects from the SET fields. In addition, in higher education institutions fees in SET are high and the cost of essential equipment and practical training is also high. In confirmation James, Naidoo and Benson (2008: 2) contend that lack of funding has a negative impact on the number of students who enter SET at higher education institutions in South Africa.

Researchers feel that socio-economic factors play an important role in learners' learning and achievement (Kanyongo, Certo & Launcelot 2006: 632; Bennet 2002: 3 of 20). Kanyongo et al. (2006: 632) believe that children living in poverty face developmental deficiencies that are most likely due to the inabilities of families to provide food, shelter and other necessities that foster the healthy cognitive development of children. These researchers cite studies undertaken by White in 1982 which found that there were relatively high correlations between SES and academic achievement. Similarly, Kennedy and Parks (2000: 533) indicate that the SES of learners has been found to be associated with differential participation of learners in science programs. Females and males who are in high SES homes completed more science courses than those from low SES homes.

Whilst most research has shown that, despite academic ability, most women avoid careers in SET, Teitelbaum (2001: 73 of 96) indicates that a scientific career itself is unattractive. For a scientific career, a PhD (and depending on the discipline, a post-doctoral fellowship) has become a minimum requirement. The cost of meeting these requirements are huge. Despite the long years of study it is sometimes impossible for students to practise as professionals in SET careers in contrast to careers in medicine, law and business.

3.6.2 Family circumstances

In African countries women's participation in education has been hampered by family care taking responsibilities (Bennet 2002: 3 of 20). Due to the division of labour in families and communities, household and societal conditions impact negatively on the ability of women in under-developed areas to remain on track with schooling (Brown 2006: 2 of 6). Mangena (2002: 2 of 3) accentuates that in distant rural areas of South Africa girls drop out of primary schools to take charge and look after household members. When family members become helpless through illness or old age, girls are often the first to be relegated to the caregiver status, thus compromising their chances of self development and success in education. Women in Science (2003-2007) documents that, in rural areas, girls are required to perform household chores after school while boys are free to go to computer clubs and internet cafes, and this hampers girls' exposure to Information and Communication Technology (ICT) sectors. Women in Science (2003-2007) accentuates that these household chores remain a burden throughout higher education and often result in women not completing their studies in SET disciplines which demand a lot of time. Assie-Lumumba (2006: 17) alludes to the fact that, in African communities, girls are usually faced with societal factors and values that pressurise them to leave school early and marry.

In confirmation Moletsane and Reddy (2008: 44) state that women already in SET acknowledge that because they are perceived as primary care-givers in society, they lack mobility to engage in work-related demands and undertake fieldwork. As a result they often drop out because they are unable to balance work with family commitments. As Tara Research and Equity Consultants (n.d.: 8) put it, "… the conflict between women's careers and household duties and child care responsibilities is an ongoing source of stress, time management and career planning challenges".

3.6.3 Distance from HE institutions

Another barrier to university access, especially for rural students, is the distance to HE institutions. This was reinforced by the establishment of historically Black universities and technikons (Koen 2003: 504). Technikons were regarded as institutions responsible for the development of scientific and high skilled labour. In the apartheid era (Koen 2003: 504) only four technikons for Black students were established: ML Sultan Technikon, Mangosuthu Technokin, Penninsula Technikon and the Vaal Triangle Technikon. The implication was that the majority of Black students from all corners of South Africa could not access these technikons because of their distance from their homes. When commenting on the position of Black universities and technikons in South Africa, Lickindorf (2005: 390) contends that these were located in "…remote and undesirable locations" with the purpose of discouraging Blacks from engaging in SET careers. Furthermore, Kuye (2004: 12) found that parents are usually overprotective of girls especially when they think they will live alone in a residence, with the result that girls might be discouraged to leave their homes.

In short, socio-economic factors are seen to hamper efforts of learners in general to participate adequately in SET careers and fields of study, nationally and internationally. The socio-economic status of the family, lack of funding in some schools and expensive courses in SET at higher education institutions negatively affect the engagement of Black students in particular in SET fields of study. And because of the low socio-economic status of the family and the distance from the universities, Black women sometimes find themselves unable to access higher education studies. Furthermore, household responsibilities are a burden to Black women. They usually have to balance family life and schooling or careers while men are free to engage in activities of their choices, with the result that Black women drop out of schools and universities and sometimes they are forced to abandon their careers.

3.7 Attitudes towards different vocations

Attitudes that students in general have, and continue to display towards SET careers, have been researched world-wide. The disturbing decline (as discussed in chapter 2) of learners' enrolment in SET and the under-representation of Black women in particular in SET careers and fields of study and the fact that the present scientific workforce is ageing, marks the global contemporary debates. Koballa (2008: 1 of 3) confirms that studies on learners' science related attitudes are once more gaining increased attention. Furthermore Sanfeliz and Stalzer (2003: 64) argue that learners' interests and attitudes are crucial features determining their entrance into science education. Therefore the rationale of this study is, inter alia, to explore learners' attitude to science learning.

There are many definitions of attitudes. Baron and Bryne (1991: 137 & 138) define attitudes as "… general evaluations people make about themselves, other persons, objects or issues. Attitudes reflect past experiences, shape ongoing behaviour and serve essential functions for those who hold them". Similarly, Khoo and Ainley (2005: 1) believe that student attitudes can be regarded as adaptable influences on participation because they are produced in response to curriculum, teaching practices and organisational arrangements of science. Cheung (2007) indicates that attitudes have three components: the affective (which refers to the feelings and emotions attached to an attitudinal object), the behavioural (which refers to actions towards the attitudinal object) and the cognitive (which has to do with one's beliefs about an attitudinal object). According to Cheung (2007), people have attitudes when they express love or hate or approval or disapproval towards the attitudinal object.

Baron and Bryne (1991: 141) indicate that attitudes can be created through direct and indirect experiences. Those attitudes that come from direct experiences are held more assertively and are more difficult to change than those formed through indirect experiences.

Smith and Mackie (2007: 2- 3 of 4) believe that attitudes can affect behaviour in two ways: they can stimulate regular behaviours directly with little interfering thoughts, and they can also shape behaviours after wide and purposeful processing, through the forming of intentions. Smith and Mackie (2007: 4 of 4) concur that if attitudes are to direct behaviour, they must get to the mind at the appropriate time.

Furthermore, science attitudes have been seen not to be influenced by cognitive abilities only but also by non-cognitive abilities such as interests, academic attitudes, study behaviours, self-efficacy and personality factors as well (Bloye 2006: 13-17 of 111) that play a role in predicting academic performance. Citing Gardner and Tamir (1989), Trumper (2006: 48) indicates that the term 'interest' usually denotes preferences to engage in a particular type of activity rather than in others, and therefore an interest may be referred to as a highly identifiable type of attitude. With this in mind it is imperative to study the effects of these non-cognitive factors on the interests and performance of women, particularly Black women in the SET fields of study and careers.

3.7.1 Self-efficacy and motivation to learn or to achieve

Self-efficacy and motivation are elements of attitudes (Bloye 2007: 13 of 11).

Self-efficacy refers to how an individual makes an educated guess about his/her capacity to successfully engage in a particular task (Jones & Burnett 2008:50; Tuan, Chin & Shieh 2005: 641; Busch 1995: 147). Prideaux and Creed (2001: 5) indicate that self-efficacy beliefs have been found to influence career decisions in males and females. Self-efficacy correlates, amongst others, with motivation to learn (Pajares 1996: 9 of 38). Tuan et al. (2005: 641) maintain that students with high self-efficacy are intrinsically motivated. Their goals will be directed towards satisfying their innate needs irrespective of whether the task is difficult or not. These students tend to persist in order to accomplish their goals (Pajares 1996: 9 of 38).

Studies have shown that college undergraduates with self-efficacy in mathematics are more likely to show interest in mathematics and mathematics related courses despite their previous performance in mathematics (Pajares 1996: 8 of 38). Furthermore, more males tend to report higher mathematical self-efficacy than females (Michaelides 2008: 229; Haley

2006: 13; Jones & Burnett 2008: 50). The same difference has been observed regarding male and female performance in computer programming (Jones & Burnett 2008: 50), but the only difference in this regard was that males had more experience with computer and computer games than females.

A study conducted by Foster (2005: 68) with female engineering students at an FET college in South Africa, indicates that Black females who did not enrol for engineering reported low self-efficacy in mathematics and science. These students did not perform well in mathematics and science at school level. Black females who enrolled for engineering reported high self efficacy in mathematics and science, and it was also found that they did well in mathematics and science. Osiruemu (2007: 105) believes that efficacy beliefs contribute more strongly to occupational preferences than do gender stereotyping. People with high self-efficacy usually consider a wider range of career options, while people with low self-efficacy eliminate a number of vocations based on perceived efficacy. Women are found to belong to the latter group and consider themselves as unsuitable for scientific careers. According to Halpern et al. (2007-2003: 6), theory and empirical research claims that children's beliefs about their abilities are key determinants of their interest and performance in different subjects and finally in their career choices.

Koballa (2008: 2 of 3) refers to motivation as "… an internal state that arouses, directs and sustains behaviour". Citing studies conducted by Brophy (1988), Koballa (2008: 2 of 3) purports that motivation to learn is a student's inclination to find academic activities significant and valuable and to try to get the planned academic rewards from them. Wlodkowski (1996: 1 of 4) contends that, while motivation is an innate ability, it becomes a personality attribute largely influenced by the process of learning. According to Wlodkowski (1996: 1 of 4), "… children learn to be interested in math, fascinated by science and intrigued with art". Therefore people who are motivated to learn find ways of overcoming their obstacles in order to succeed.

In a study conducted by Tuan et al. (2005: 642) learners indicated that their motivation to learn science was due to the learners themselves, the teachers' performance and the relevance of the science content. These learners also declared that their motivation to learn is extrinsic (e.g. competition and pleasing the teachers) as well as intrinsic (satisfying their needs).

Research has indicated that as early as primary school, boys and girls show different attitudes towards science and technology, and when they reach secondary schools girls, more than boys, show a decline of interest in science and mathematics (Kahle & Damnjanovic 1997: 5; Monhardt, et al. 1999: 533; Wasburn & Miller 2004: 156; Gray 2005: 2 of 16; Trumper 2006: 47-48; Gough 2007: 6). Trumper (2006: 48) authenticates that negative attitudes towards a subject can affect learners' interests in that subject and as a result this subject can be avoided when learners have to choose their fields of study. A positive attitude towards science can result in a positive commitment to pursuing lifelong learning and eventually careers in science. Russell and Peacock (2005: 24) believe that women in general lack interest in science more than do men. These researchers indicate that attitudes and beliefs in science vary according to age, gender, education and other factors such as attitudes towards life. Various researchers have attributed these negative attitudes to science to socialisation processes which eventually lead to occupational sex role stereotypes (Haley 2007: 4-5; Gray 2005: 5 of 16).

3.7.2 Occupational Sex-role Stereotypes

Gender stereotyping is part of women's attitude towards science. Osiruemu (2007: 106) stresses that gender role is the explicit expression of attitudes that suggests to others the extent of a person's maleness or femaleness. Furthermore, gender stereotyping is an array of behavioural standards related to males and females in a specified social system. Therefore females in general have fallen prey to gender stereotyping according to which women are not supposed to fill certain occupations. This is even more so for Black women who also have to contend with racial stereotyping (Case & Jawitz 2002: 8). Case and Jawitz (2002: 8) indicates that interviews conducted with Black male and female chemical engineering 'vacation work students' in a South African University, revealed that issues of race and gender frequently interacted with experiences of being taken seriously in participating in vacation work. These students were not taken seriously and sometimes they were not regarded as potential engineers but rather as some kind of labourer because one Black male student indicates that "… he was told to make tea by a White superior, and feeling that he had no alternative but to obey this order".

Moletsane and Reddy (2008: 13) document that gender stereotypes and attitudes come from values held by families, society and media pressures as well as by the education system. All these factors play a role in determining beliefs, ideas and values. Therefore, these misguided expectations direct women to gendered classification of workers which promotes unequal distribution of women across a variety of occupations and industries.

Miller and Hayward (2006: 70) refer to occupational sex-role stereotypes as beliefs concerning the sex which should perform particular jobs and occupational sex segregation is the degree to which the workforce is actually split along gender lines in an occupation. Guimond and Roussel (2001: 278) refer to gender stereotypes as "legitimizing myths" where certain psychological processes maintain that men are dominant over women in mathematics and science.

Research results have shown that from an early age, even before attending school, females are socialised by societal beliefs "…that a woman's role is to simply serve, nurture and care" (Moletsane & Reddy 2008: 14). These stereotypes (Frehill et al. 2005: 41) are then put forward to affect girls' performance and participation in science and mathematics at school.

Studies have revealed that socialisation processes can make children internalise sex roles which influence their occupational choices. Research undertaken at the University of Minnesota (Kahle & Damnjanovic 1997: 5), documents that boys and girls learn 'gender correct' behaviour that is expected by society by 24 to 26 months of age. At that age boys and girls have already learnt stereotypical behaviours. Osiruemu (2007: 106) affirms that the progression through which individuals study socially appropriate behaviours is called socialisation. This socialisation makes children internalise sex roles which influence their occupational choices when they grow up. Kahle and Damnjanovic (1997: 5) found that boys were able to tell what they would and would not do, more so than girls. These researchers also found that when kindergarten children were interviewed three weeks after they had enrolled at school, they were not able to define science, but more boys than girls wanted to be scientists and indicated that they were good at science. These findings suggest that career choice patterns might be established as early as kindergarten age. In addition, Kennedy and Parks (2000: 532) believe that the choice of clothing, activities and toys play a major role in shaping a girl's sense of herself.

The education system can also contribute to sex-role stereotypes. Mabandla (1998: 32) feels that, in addition to racial stereotypes in the education system of the past in South Africa, there was stereotyping of women in science. Mabandla (1998: 32) states that "…instead of liberating young women and girls, education became an enslaving force". Science was seen as a man's territory, and women were regarded as incompetent to study 'difficult' scientific subjects, with the result that they were channelled to studying humanities.

Engle (2003: 6) purports that although legal obstructions to women's engagement in education and employment have been removed, social barriers are still eminent. The segregation of women and men in employment mirrors and strengthens stereotypes about gender type occupations. These stereotypes display the image of science as masculine. Knight and Cunningham (2004) contend that images are strong methods of communication and that humans construct images in order to make sense of their daily experiences. Gough (2007: 3) believes that these images can be persuasive in shaping beliefs and attitudes and can perform an important role in forming and developing identities.

3.7.2.1 Media images

Researchers have witnessed stereotypical representations of scientists in Western literature (Gough 2004: 4). In addition, Knight and Cunningham (2004) purport that the public does not have an adequate understanding of engineers and engineering as a profession. The same was discovered in a study conducted in South Africa in which educators from disadvantaged areas were requested to rate their own knowledge of the engineering profession (Horak & Fricke 2004). Haynes (in Gough 2007: 4) states that the majority of learners' representations of scientists depict scientists negatively but verifies that these depictions have not only reflected writers' opinions of the science and scientist of their era but in turn have provided a model for the current evaluations of scientists and science.

In searching present day secondary school learners' understanding, attitudes and images of science and the scientist, many different strategies have been used. A "Draw-A-Scientist Test" (DAST) has been used by researchers in science education research in order to identify the development of identity and the creation of self in the science classroom, [Reiss 1993: 19; Makate 2000: 60-62; Knight & Cunningham 2004 and Chambers (in Gough 2007: 6)]. Chambers saw a DAST as useful in identifying rather than measuring attitudes. Chambers mentions that the standard mythic images of a scientist which appeared prior to his work were the following:

- *Lab coat (not necessarily white)*
- *Eyeglasses*
- *Facial growth of hair*
- *Research symbols, e.g. laboratory equipment and instruments*
- *Knowledge symbols, e.g. books and filing cabinets*
- *Technology (the products of science)*
- *Relevant captions (formulae, taxonomic classification, etc.)* Gough (2007: 6).

According to Chambers (in Gough 2007: 6), research done on images of science and the scientist was undertaken with children, adolescents and college students. Chambers observed that the number of indicators of the traditional image of the scientist increased as the respondents became older. To ascertain if Chamber's traditional image of the scientist was still held by children and scientists, Botwell (in Gough 2007: 7) used a slightly adapted form of the DAST, a questionnaire and an interview. Little differences were found because although grade 5 and 6 students portrayed stereotypical images of scientists, interviews showed that scientists were viewed as ordinary people. Secondly, the study reported that adults and scientists usually put forward illustrations of stereotypical images of the scientist including Chamber's indicators of a scientist. Furthermore, children have a tendency of portraying few women as scientists as reflected from the DAST.

Similar findings were attained in a DAST in a primary school in the Xhariep district in the Free State (Makate 2000: 60-62). The researcher's aim was to determine gender inequities in science education. In grade 4 drawings, 94.3% of boys' drawings were of males while only 5.7% were of females. Ninety-three comma six percent of girls' drawings resembled females, while 6.4% resembled males. It was evident that the learners portrayed themselves (or persons of the same gender) in their drawings. Furthermore, other features of scientists according to their drawings, dealt with maps, weather, flying aeroplanes as well as a few drawings of female doctors and nurses. Most of the drawings, however, indicated that learners did not know exactly what a scientist is and does. It was also evident that many of them had never seen pictures of scientists in books before.

In a study conducted by Makate (2000: 60-62) it was found that most of the grade 5 learners depicted a scientist as male (84.2 % of boys and 68.8% of girls seemingly held these perceptions). In respect of grade 6 learners, however, boys predominantly depicted scientists as male while girls depicted scientists as females. From these results it was deduced that the differences between grade 5 and 6 girls' responses could be due to the fact that the selected grade 5 class was taught by a male educator, while the grade 6 class was taught by a female educator. It thus seemed that, for learners with limited knowledge and experience, scientists resembled their own educators. Similar findings were reported by Knight and Cunningham (2004) with grades 9 to 12 learners in Boston. Results indicated that females were more likely to draw female scientists than males. Most of these drawings came from classes which were taught by two female undergraduate engineering students from Tufts University who had been teaching learners for a few months.

A study conducted in England by Miller and Hayward (2006: 85), examined the influence of occupational sex-role stereotypes and perceived gender segregation in regard to job preferences in learners aged 14 to 18 years. Boys preferred jobs that they believed should be carried out by boys and girls preferred jobs that they believed should be executed by girls. For girls these beliefs notably moderated with age. The relationship between the liking of the job and the assumed gender segregation and stereotypes, moderated between the ages of 16 and 17 and disappeared gradually by the time girls reached the ages of 17 and 18. For boys the relationship remained substantial between the ages of 14 to 18 and did not weaken at all. By the time women start to think fully about a wide range of jobs as appealing options (17-18 years), crucial decisions about qualifications would have already been completed, impeding the real alternatives available to them (Miller & Hayward 2006: 85). This study also examined the impact of both occupational sex-role stereotypes and occupational sex segregation. The data revealed that views of occupational sex-role stereotypes (who should do the job) change with age but views on the extent to which an occupation is gender segregated (what is the case really in the actual working environment) do not.

From these findings Miller and Hayward (2006: 86) conclude that stereotypes are systems of beliefs which are subject to correction as the child's world-view fully develops, while estimates of gender segregation are based on comparatively true perceptions of the working environment, which are difficult to change unless the environment itself changes.

A study conducted in Australia by Gough (2007: 11) discovered that secondary school learners acknowledge the importance of science and technology for society but do not regard themselves as part of it. They are not interested in studying science at secondary school or pursuing careers in science.

Klawe (2000: 61) indicates that television is of particular importance in shaping children's attitudes and behaviours. In America children's television programs have been found to propagate the stereotype of the scientist as male and images are usually negative and incorrect. Klawe (2000: 63) found that 75 percent of the scientists on prime time television were White males. Her studies concluded that if children go along with examples from television, there will be hardly any females and other minorities in science occupations in future.

Hamilton, Anderson, Broaddus and Young (2007: 1 of 13) confirm that gender discrimination in picture books is detrimental to children. Hamilton et al. (2007: 2 of 13) indicate that female characters are still under-represented in children's picture books and that these stereotypical portrayals of the scientist contribute negatively to children's advancement. These stereotypes (Hamilton et al. 2007: 1 of 13) further restrict their career choices, construct their attitudes about their imminent roles as parents and manipulate their personality characteristics.

Research indicates that women experience problems in science classrooms. Those women who managed to survive the uninviting science classrooms and enter the scientific community still find it difficult to cite their work as scientific even if their education and professional practices are based on scientific principles. These women (Liebenberg 2002: 3) may silently abandon the profession. Women's work in the sphere of health care, even when shown to be organised, meticulous and valuable, is rarely labelled as science. Women's work in the traditional scientific male dominated fields, have also been overlooked (Bebbington 2002: 366). In confirmation, Gray (2005: 6 of 16) indicates that there is lack of acknowledgement of contributions and accomplishments of women in scientific textbooks and a lack of female educators and professors in the sciences. This indicates that female achievements in science are often ignored or marginalised.

Occupational segregation has been noticed in the labour market. A study undertaken in the United Kingdom includes some evidence that women in SET occupations have difficulty in merging the competing demands of professional and family life and that these conflicts are marked for women in traditionally male dominated occupations (Bebbington 2002: 364).

Monhardt et al. (1999: 534) cite the research done by Kubanek and Waller (1995) who found that younger women, unlike their male counterparts, were indecisive about choosing a career in science because of the 'superwoman' image that is obligatory when managing a science career as well as a family. In this regard Ferganchick-Neufang (1998: 5 of 14) states that women are constantly asked to prove themselves because the social order continues to think that the "…weaker sex extends past physical ability and into mental ability".

Rayman (2001: 65 of 96) indicates that the culture of science is based on aggressive behaviour and is gender biased. Rayman (2001: 65 of 96) feels that this type of climate has succeeded in attracting and retaining males, who thrive under such conditions, and disposed of those who do not thrive. On the other hand, gender specific socialisation typifies women to be less competitive, less self-driven, more relational and more apt to have multiple role identities (care-givers and scientists). It is this culture which drives women away.

Halvorsen (2002: 347) distinguishes between a "Knowledge Society" and a "Professional Society". In a "Professional Society" expertise is found in the professional elite (e.g. lawyers and doctors), whereas a "Knowledge Society" is the one in which education which can enhance expertise is within reach of and available to everyone. Halvorsen (2002: 347) believes that the distribution of knowledge leaves out part of the population based on predetermined social prescripts such as gender, class and ethnicity. Reference is made to the UK where even though the “Professional Society” is being eroded, traces of a masculine culture are still universal. On this note Halvorsen (2002: 355) feels that women are likely to continue to be disadvantaged with regard to their employment, promotion opportunities and appointments to permanent positions despite a shift from a “Professional” to a “Knowledge-based” Society.

Furthermore, Teitelbaum (2001: 77-78 of 96) states that a scientist will be 35 to 40 years of age before obtaining his or her first permanent job. Those in search of academic careers must spend 6 years of conditional appointment as assistant professors. As a result a stable appointment can be achieved at about 31 years of age for mathematics and about 40 years of age or older for the life sciences. When comparing careers in engineering, with careers such as medicine, law or business, a graduate can acquire full professional status at about the age of 28 for medicine, and the age of 26 for business and law. It is likely that fields in which a career cannot be firmly established before the middle or early 30s can place special stress upon women who want to be married and have children.

3.8 Influence of role models

Monhardt et al. (1999: 539) believe that mentoring or the lack of a mentor influences career choices of women. In their study these researchers found that women scientists indicated that they were handicapped in pursuing their careers because of lack of information and encouragement that might have assisted them to advance professionally. Research has indicated that SET careers endorse a masculine territory (Disken 2000: 51). Because of this it might be difficult for women to find mentors like men do since individuals find it easier to mentor people who are like themselves. Tara Research and Equity Consultants (n.d.) indicate that women prefer women mentors in the hope of finding a compassionate mentor because they need a sympathetic relationship.

Lack of role models has been found to influence career choices of learners. De Santis, (2006: 2) defines role models as “… people whose lives and activities influence another person in some way”. Studies conducted by Brownlow et al. (2000: 121) document that adult role models do influence children's beliefs about appropriate careers. De Santis (2006: 2) states that since children are more likely to engage in activities similar to those of their gender or race, girls find themselves not having enough role models in SET careers and fields of study because there are few women scientists. Citing research done by Gilbert (1985) and Smith and Erb (1986), De Santis (2006: 2) further indicates that students regard role models as important for women who want to follow non-traditional careers.

Similarly, Foster (2005: 40 - 41) documents that there are few women educators who teach science and technical subjects at secondary schools and higher education institutions and therefore females have little chance of being influenced by them. In addition, lack of same sex and same race educators impacts negatively at secondary school as well as in tertiary institutions. In the absence of role models women are anxious about ways of dealing with their problems.

Peers are also found to play a role in career aspirations of adolescents. Foster (2005: 44) notes that not much research has been done on the influence of peers on careers, but studies undertaken show that adolescent boys and girls have an influence on the career choices of other adolescents in SET. Foster (2005: 44), citing studies conducted by Baker and Leary (1995), indicates that girls show more positive attitudes to careers in SET when they have a friend studying SET, and have fewer stereotyped views concerning science and science related fields. A study conducted by The Center for Women and Work and The John Heldrich Center for Workforce Development (2002: 6 of 28), indicates that when workers were asked who encouraged them in their current jobs they indicated that they were encouraged by their friends.

3.9 Conclusion

In this chapter several factors influencing vocational choices of Black women have been discussed. It has been shown that there are cognitive and non-cognitive factors that might influence career choices of Black women. Furthermore, there are also very practical factors including socio-economic factors, family circumstances and the distance from HE institutions which might also inhibit Black females from pursuing SET studies in HE. Another factor might be lack of role models which can be an educator, a parent, peers or any other person that might influence Black girls to enrol in great numbers in SET.

To conclude, research results authenticate that attitudes play an important role in occupational choices of adolescents. Children's attitudes towards SET careers are influenced by a variety of factors, such as self efficacy, interest and motivation. Gender stereotyping is found to be an explicit type of attitude towards science related fields according to which women should not choose scientific careers. These attitudes are formed because of experiences and societal beliefs about the expected roles of males and females. The function of socialisation promotes desirable and suppresses undesirable behaviour. Therefore women in general, and Black women in particular, are the ones who will most probably stay invisible in the SET fields of study and careers unless societal beliefs change.

The empirical research undertaken in this study specifically focuses on two factors possibly influencing career choices of Black women in SET, namely, attitudes and occupational sex-role stereotypes towards the natural sciences. In the next chapter the research design and methodology employed in the research are discussed.

CHAPTER 4

METHODOLOGY

4.1 Introduction

Chapter 2 provided a hypothetical background to the under-representation of Black women in SET fields of study and workplaces. The literature review provided statistics which show that Black women in particular do not perform well in science subjects at school (especially mathematics and physical science). These may be contributing factors to the grossly under-representation of Black females in SET fields of study and careers in HE institutions (see 2.2.8).

In Chapter 3 possible factors were considered that might affect career choices of women in general and Black women in particular. A conclusion was drawn that amongst many factors cited in the literature, it was necessary to investigate the attitudes and occupational sex-role stereotypes of Black women in the natural sciences in a specific South African context. In this way a contribution could be made to knowledge production in the fields of education/higher education in particular, in the sense of a better understanding of why Black females are under-represented in SET fields. This should be regarded as the overall goal of the study. Such knowledge could ultimately pave the way for measures by means of which the problems could be appropriately addressed.

This chapter is particularly concerned with the research design and the appropriateness of the different kinds of research methods employed in the particular study. It further aims to describe the conditions under which the methods were used for different kinds of data collection, analyses and reporting.

The study must be seen against the research problem, as argued in chapters 1, 2 and 3, and as summarized below.

4.2 Statement of the research problem

The research problem in this study centres on the problem of under-representation of Black females in SET and most often, lower achievement of these females in most instances. Many factors might possibly contribute to the situation, including sex-role stereotypes and females' attitudes regarding the natural sciences (see 3.6). In South Africa, factors contributing to the under-representation are not well known and not extensively researched, in particular in rural areas. In the light of this the general research question that gave rise to this research can be stated as follows:

Is there a relationship between science attitude and occupational sex-role stereotypes among rural Black females and the entrance into natural sciences studies in Higher Education?

The criterion for entrance into natural science studies will be the marks of grade 12 rural Black females obtained in the subjects: biology, physical science and mathematics, combined with the results obtained from Entrance Tests in many HE institutions as stipulated by HESA. Therefore the specific research question is as follows:

Is there a relationship between science attitude and occupational sex-role stereotypes among rural black females and marks in biology, physical science and mathematics?

The research question gave rise to the following hypotheses.

4.3 Hypotheses

The null hypothesis 1: *There is no relationship between science attitude and marks of rural Black females in biology, physical science and mathematics.*

The alternative hypothesis 1: *There is a positive relationship between science attitude and marks of rural Black females in biology, physical science and mathematics.*

The null hypothesis 2: *There is no relationship between occupational sex-role stereotypes and marks of rural Black females in biology, physical science and mathematics.*

The alternative hypothesis 2: *There is a positive relationship between occupational sex-role stereotypes and marks of rural Black females in biology, physical science and mathematics.*

The hypotheses will be tested using a 0.05 level of significance.

4.4 Aims of the study

The aim of the study was to investigate the relationship between science attitude and occupational sex-role stereotypes and marks in biology, physical science and mathematics of rural Black females.

4.5 Identifying the variables

The nature of the independent and dependent variables are discussed in this section.

4.5.1 Independent variables

The two independent variables in this study are science attitudes and sex-role stereotypes

4.5.1.1 Science Attitudes

Pasquier, Rahwan, Dignum and Sonenberg (2003: 5) refer to attitudes as constructive or destructive psychological dispositions towards a real or imaginary object or behaviour. Pasquir et al. (2003: 5) further indicate that attitudes are important elements of cognition and that "… the beliefs (cognition) and desires (affect) lead to intentions which could lead to actual behaviours or dialogical attempts to get the corresponding social commitments depending on their nature".

For the purpose of the study the operational definition of science attitude will be described as the score obtained from the Science Attitude Scale for Middle School learners (Appendix A Section B).

4.5.1.2 Occupational Sex-role Stereotypes

Occupational sex-role stereotypes are beliefs concerning which sex should perform certain jobs (Miller & Hayward 2006: 70). Guimond and Rousell (2001: 278) purport that these stereotypes operate as “legitimizing myths” which can activate certain psychological processes that will play a role in upholding the status of men as having authority over women in mathematics and science.

The operational definition of Occupational Sex-role Stereotypes in this study is described as the score obtained from the job stereotype questionnaire (see appendix A section C)

4.5.2 Dependent variable

The dependent variable in this study is academic achievement, as explained below.

Academic achievement in biology, physical science and mathematics

Bloye (2007: 16 of 111), in reference to Kobal and Musek’s (2001) definition indicates that academic achievement has to do with the numerical points of a learner’s knowledge, indicating a level of a learner’s adjustment to school work and the educational system.

For the purpose of this study, academic achievement will be defined as the marks in biology, physical science and mathematics as obtained from the grade 11 November 2008 results only. It was impossible to get marks for the June 2009 results because some schools did not write the grade 12 June 2009 examinations.

The operational definition of academic performance is described as the marks obtained in biology, physical science and mathematics as reflected in the grade 11 November 2008 results.

The confounding variables identified in the study are described in the next section.

4.5.3 Confounding variables

Confounding variables can also be referred to as extraneous variables or intervening variables (Wright & Lake 2006: 5 of 15). If not controlled, these factors can influence research results. To ensure that research results are not confounded, confounding variables were built into the design, measured and analysed to determine whether they have a significant effect on the dependent variables or not. The confounding variables in this study are:

4.5.3.1 Ethnicity

The American Anthropological Association (1997: 3 - 6 of 9) indicates that 'race' and 'ethnicity' are not clearly distinct concepts. Prevalent connotations of 'race' tend to be related with physiology and those of 'ethnicity' with culture. Ethnicity may be defined as the classification of the population groups which are distinguished by common ancestry, language and custom. Ethnic groups often share physiology, which become part of their identification.

For the purpose of the study, to be operationally defined, ethnicity will be measured as a categorical variable.

4.5.3.2 Psychosocial background factors

The term 'psychosocial' is widely used in literature in the context of health research and social epidemiology. Psychosocial factors can be regarded as influences acting mainly between the social (effects of social factors) and the individual (the individual's mind or behaviour) level and to the interrelatedness of behavioural and societal factors (Martikakeinen, Bartley & Lahelma 2002: 2 of 7).

For the purpose of the study, psychosocial background factors will be operationally defined as a score on the Scale measuring Psychosocial Background Factors (see appendix A section D).

The research design and methodology employed in the study are discussed below.

4.6 Research design and methodology

A quantitative research design was regarded mostly appropriate to conduct this multivariate empirical study. Since non-experimental research designs use types such as descriptive, correlational, ex post facto and survey research (McMillan & Schumacher 1993: 266-293), a non experimental research inferential multivariate research design in the form of a survey was employed. The rationale for choosing a survey research is that "… most surveys describe the incidence, frequency and distribution of the characteristics of an identified population". "… surveys can also be used to explore relationships between variables, in an explanatory way" (McMillan & Schumacher 1993: 280)

Furthermore, a quantitative design, as stated by Kellinger (1986: 10), the renowned author in the field of research methodology, refers to "…a systematic, controlled, empirical and critical investigation of natural phenomena guided by theory and hypotheses about the presumed relationships among such phenomena. This study could determine whether there is a correlation between science attitudes and occupational sex-role stereotypes and marks in biology, physical science and mathematics.

4.6.1 The test group

The target population was all Black females in grade 12 in the Xhariep district. However, only grade 12 Black females from 5 schools were selected for the sample.

Sampling of institutions and respondents took place purposefully and conveniently. Sampling comprised 112 grade 12 females from the rural parts of the Xhariep district in the Southern Free State province of South Africa. Participants were selected on the basis of proximity of schools and informed consent from the Department of Education, principals and students. Because of the vastness of the Xhariep district, small towns which are far apart from each other and small grade 12 classes, it was impossible to obtain a large sample. The schools were similar because they were all Black township schools.

Sample inclusion took place according to the following criteria:

- Grade 12 – 2009 enrolments;
- Gender – only females;
- Ethnicity – all African;
- Language – all African languages;
- English as medium of instruction; and
- Informed consent from participants.

4.6.2 Data collection

Permission was granted to gain access to 5 secondary schools in the Xhariep rural areas of the Southern Free State. Participants were gathered in the school hall and the letter of consent was read to participants in the presence of an educator who was assisting the researcher. Participants were requested to ask questions if there was anything they wanted clarity on before they signed the consent forms. The educator also signed as a witness that participants were not forced to participate in the study.

Before the instruments were administered, the researcher explained what was required of the participants and how to complete the instrument. The questionnaire was divided into sections. In Section A participants had to provide their biographical information. Section B was a questionnaire on the Science Attitude Scale for Middle School learners. The six point scale questionnaire ranged from ‘completely disagree’ to ‘completely agree’. Participants were requested to indicate their responses by making a cross in the box of their choice. Section C was a questionnaire measuring

Job Stereotypes. The six point scale questionnaire ranged from ‘completely disagree’ to ‘completely agree’. Participants had to indicate their responses by making a cross in the appropriate block of their choice. The last section measured the Psychosocial Background factors of learners. Participants had to rate the given aspects of their lives by marking the block closest to the description of that aspect on a six point scale. The scales were scored and handed to the statistician for analyses of results. Marks in biology, physical science and mathematics were obtained from the grade 11 November 2008 results.

4.6.3 Research instruments

For the purpose of the study the following instruments were used:

- The Science Attitude Scale for Middle School Students;
- The scale measuring Occupational Sex-role stereotypes; and
- The scale measuring the Psychosocial Background factors of students.

4.6.3.1 The Science Attitude Scale for Middle School Students (adapted)

The scale has been used among American middle school learners over the past two decades and completes the composition of three generations of instrument development (Misiti, Shrigley & Hanson 1991: 525). Initially the scale was a 33-item Likert scale designed for grade 6 students in which the effects of “handmade and commercial science equipment” on the attitudes towards science were measured. Misiti et al. (1991: 525) confirmed that the scale lacked validation ratings.

The second generation redesigned the scale to test science attitudes of a number of grade 4, 5 and 6 students whose teachers were engaged in a district in-service project for three years. The scale was never published. After many years many researchers applied for permission to use it. Mohammed Salim translated it into Arabic and administered it to grade 5 Egyptian students. The scale consisted of 14 positive and 13 negative statements. Later it was administered to 70 grade 4 and 102 grade 5 students. The coefficient alpha for the two sets of data was 0.86.

According to Misiti et al. (1991: 527), the third generation of instrument development, which informed procedures for revisiting the scale, is the work of Koballa (1984); Abdel-Gaid et al. (1986); Thompson et al. (1986) and Calhoun et al. (1988). These researchers suggested that if the scale is amended it should be published. In this scale validation procedures not mentioned by the scales cited earlier were tried. Procedures included calling middle school children into the jury process, trying out the scale for evaluative quality and cross-cultural examination. The target population comprised grades 5, 6, 7 and 8 learners. Twenty-three Likert type items were ultimately chosen with the following subcomponents:

Subcomponent 1: Investigations – eight items

Subcomponent 2: Comfort/discomfort – six items

Subcomponent 3: Learning science content – four items

Subcomponent 4: Reading and talking about science – three items

Subcomponent 5: Viewing films on TV – two items (Misiti et al. 1991: 533).

The data generated from 206 subjects on 23 items and from 109 middle school learners on the same items produced coefficient alphas of 0.96 and 0.92 on both sets of data respectively, convincingly suggesting interconnectedness of the items (Misiti et al. 1991: 534).

The rationale for using the Science Attitude Scale for Middle School Students is that researchers, including Misiti et al. (1991: 525), claim that it is during these years (late primary) in which attitudes that influence the choice of science courses at secondary schools and colleges are formed. And because the scale has passed a number of tests for validity it could be used with secondary school learners (Misiti et al. 1991: 538). Therefore it was considered applicable to grade 12 students because the respondents in this sample were English second language speakers.

4.6.3.2 The Scale measuring Occupational Sex-role Stereotypes

Miller and Hayward (2006: 74) designed a questionnaire based on the one used in Miller and Budd (1999). The scale was extended to take into account the extent to which occupational gender segregation and occupational sex-role stereotypes influence young people's liking for, and knowledge of, jobs. In the first section for each of the 23 listed jobs, learners were requested to rate their job knowledge. In the second section, the questionnaire provided a short definition of each occupation in which subjects were asked three questions in order to assess the extent to which a job was viewed as stereotyped; the extent to which a job was gender segregated, and lastly preferences or liking of the job. The scale was administered to 222 girls and 286 boys in England between the ages of 14 and 18.

For the purpose of this study only the section measuring occupational sex-role stereotypes was used. The scale was modified and only a list of non-traditional occupations was used in which a short definition of each occupation type was given. Furthermore, the test was only administered to girls. The Cronbach Alpha of the scale as used in this study was 0.95. The scale has obvious construct validity.

4.6.3.3 The Scale measuring Psychosocial Background factors of learners

The psychosocial background factors questionnaire is divided into four subsections measuring emotional support, socio-economic situation, environment conducive to learning and depression. Participants were required to make a cross in the box closest to the description of the aspect. The scale was developed by Viljoen (2007) and has a Cronbach Alpha of 0.83 which is satisfactory for internal consistency. The questions of the scale indicate that it has construct validity.

The following section concerns the analyses of data.

4.6.4 Analysis of results.

Data analyses was done by Professor Schall of the Department of Statistics at the University of the Free State using descriptive univariate and multivariate analyses. The data analysis plan provided by Prof. Schall (2009) (Appendix C) was used.

4.6.4.1 Objective of statistical analysis

The principal objective of statistical analysis is to explore the effect of science attitude and job stereotypes on science marks, while controlling potential confounders such as age, ethnicity and psychosocial background factors.

4.6.4.2 Descriptive analysis

Frequency tabulations (number of learners and percent of learners per category) for the following variables will be presented. The Statistical Analyses Plan of Professor Schall (2009) is used verbatim in this section.

- *Ethnicity*

***Software**: SAS Proc FREQ.*

Descriptive statistics (mean, SD, median, mean, max, number of observations) will be presented for each quantitative variable, namely

- o *Score on Science attitude scale for middle school children*
- o *Score on Job stereotypes*
- o *Marks in biology*
- o *Marks in physical science*
- o *Marks in mathematics*
- o *Age*
- o *Psychosocial background score*

***Software:** SAS Proc MEANS*

4.6.4.3 Univariate analysis

The three dependent variables are the following:

- o *Marks in biology*
- o *Marks in physical science*
- o *Marks in mathematics*

Each dependent variable will be analysed using one-way ANOVA fitting the categorical confounding variable:

- *Ethnicity*

Each dependent variable will be analysed using simple linear regression fitting (one at a time) of the following variables:

- *Score on Science attitude scale for middle school children*
- *Score on Job stereotyping*
- *Age (continuous)*
- *Psycho-social background score (continuous)*

Software: *SAS Proc GLM*

4.6.4.4 Multivariate analysis

Each independent variable will be analysed using linear regression and analysis of covariance techniques. Initially, the analysis of a covariance model for each dependent variable will contain the two independent variables (score on Science attitude scale for middle school children and score on Job stereotyping) and all potential confounders (age, ethnicity and psychosocial background score) F-statistics and associated P-values will be calculated for each variable in the model. Stepwise model selection will be applied by removing, one at a time, that variable among the confounders which is least significantly associated with the outcome, providing that the P-value is at least 0.1.

Software: *SAS Proc GLM* (Schall 2009).

4.7 Reliability and validity of the research

4.7.1 Reliability

In quantitative research reliability is determined by the reliability of the measuring instruments and applying the correct statistical techniques. McMillan and Schumacher (1993: 227) define reliability as the constancy of measurement, the degree to which similar results are reported over different forms of the same instrument or instances of data collecting. Trochim (2006: 1-7 of 7) states that there are four types of reliability estimates, namely Inter-Observer Reliability, Test-Retest Reliability, Parallel-Forms Reliability and Internal Consistency Reliability. For the purpose of this study Internal Consistency Reliability estimates were used. In internal consistency reliability estimation, a single measurement instrument is administered to the target population on one instance to measure reliability. The reliability of the instrument is ascertained by estimating how the items that show the same construct produce consistent results (Trochim 2006: 3-4 of 7). Since the Cronbach Alpha of the scale measuring science attitude was 0.96 and 0.92 on both sets of data respectively (4.6.3.1), 0.95 on the scale measuring occupational sex-role stereotypes (4.6.3.2) and 0.83 on the scale measuring psychosocial background factors (4.6.3.3), the scales have proven reliability. According to Trochim (2006: 6 of 7) "… Cronbach's Alpha tends to be the most frequently used estimate of internal consistency". Santos (1999: 2 of 4), citing Nunnaly (1978) indicates that 0.7 is an acceptable reliability coefficient.

Furthermore the instruments used were at the appropriate reading level and language of grade 12 learners. All respondents were given the same directions, answered the questionnaire within the same time frames at the same time during the day (McMillan & Schumacher 1993: 230-231). Because the questionnaires and scales have proven reliability, the reliability of the research is assumed.

4.7.2 Internal validity and external validity

Mcmillan and Schumacher (1993: 223) indicate that validity is a judgement of the correctness of the measure for exclusive decisions that emanate from the scores that result from the study. Lee (2007: 61), drawing on Pedhazur and Schmelkin (1991), refers to internal validity as the validity of results concerning the effects of the independent variable(s) on the dependent variables. Internal validity (McMillan & Schumacher 2006: 118) controls confounding variables by building a possible confounding variable into the design as another independent variable. Therefore Maas (1998: 24) refers to internal validity as the degree to which variations in the dependent variable are accounted for by differences in the independent variable and not by any extraneous or third variable. Because extraneous variables were measured and accounted for as far as possible, internal validity was obtained.

External validity, on the other hand, is the degree to which results of the study can assertively be generalized to the population from which the sample was drawn (Kellinger 1986: 300). Because random sampling was not done in this study, external validity cannot be claimed.

4.8 Conclusion

This chapter explained the methodology employed in the study. The statement of the research problem was presented followed by the underlying hypotheses. The aims and the objectives of the study were presented and the independent, dependent and confounding variables were identified and operationally defined. A quantitative research design approach was presented in which information regarding the test group, data collection procedures and the research instruments was provided. The data analyses plan was highlighted in which a descriptive univariate and multivariate analyses were used to analyse the data. Reliability and validity of the research was presented. The results of the present study are reported and discussed in the next chapter.

CHAPTER 5

RESULTS AND DISCUSSION OF RESULTS

5.1 Introduction

The primary objective of the statistical analysis was to determine whether there was a relationship between science attitudes, occupational sex-role stereotypes and academic achievement in biology, physical science and mathematics of 112 grade 12 rural Black females. The respondents completed a six point scale questionnaire measuring science attitudes, job stereotypes and psychosocial background factors. In the first section of the questionnaire respondents were required to fill in their biographical information. Academic achievement was measured in terms of marks in biology, physical science and mathematics. A discussion of the research results will be presented in this chapter.

5.2 Descriptive Analyses

5.2.1 Descriptive analysis: Categorical confounding variables

The only categorical variable is ethnicity.

Table 1: Ethnicity of respondents in the sample

Description	Frequency	Percentage	Cumulative Percentage
S. Sotho	67	63.21	63.21
Xhosa	39	36.79	100.00

The data collected indicate that there were 67 South Sotho learners in the sample, which amounted to 63.21 percent. There were 39 Xhosa learners with a percentage of 36.79. The cumulative percentage of the test group was 100.00.

5.2.2 Descriptive analysis: Continuous confounding variables

The continuous confounding variables are age and psychosocial background factors.

Table 2: Age and Psychosocial Background factors.

Variable	N	Mean	Std Dev	Minimum	Maximum	Median
Age	112	19.11	1.47	17.00	23.00	19.00
Psychosocial factors	112	31.05	12.31	14.00	71	29.50

There were 112 respondents in the test group. Research results indicate that the mean score of the respondents was 19.11, the standard deviation was 1.47. The minimum age of the respondents was 17.00, the maximum age was 23.00 and the median was 19.00. The table shows that there were students between 20 and 23 years of age in the test group. These students are regarded as old to be in grade 12.

112 respondents completed the psychosocial background questionnaire. The mean score was 31.05, the standard deviation was 12.31, the minimum score was 14.00, the maximum score was 71 and the median was 29.50.

The independent variables are science attitude and occupational sex-role stereotypes.

Table 3: Descriptive analysis continuous independent variables: Science Attitude and Occupational Sex-role Stereotypes

Variable	N	Mean	Std Dev	Minimum	Maximum	Median

Science A	112	65.45	15.91	23.00	111.00	66.50
Job S	112	106.96	21.73	30.00	138.00	108.00

Regarding the science attitude, 112 students completed the questionnaire. The mean on the science attitude scale was 65.45, the standard deviation was 15.91, the minimum score was 23.00, the maximum score was 111.00 and the median was 66.50.

Concerning the job stereotype scale, 112 students completed the questionnaire. The mean on the job stereotyping scale was 106.96, the standard deviation was 21.73, the minimum score was 30.00, the maximum score was 138.00 and the median was 108.00.

The dependent variables are biology, physical science and mathematics.

Table 4: Descriptive analysis continuous dependent variables: biology, physical science and mathematics.

Variable	**N**	**Mean**	**Std Dev**	**Minimum**	**Maximum**	**Median**
Biology	44	37.80	7.50	24.00	55.00	38.00
Physical Science	33	39.85	7.13	24.00	52.00	40.00
Mathematics	38	33.24	10.82	15.00	64.00	32.50

44 respondents in the study took biology as a subject. The mean mark was 37.80, the standard deviation was 7.50, the minimum mark was 24.00, the maximum mark was 55.00 and the median was 38.00.

33 respondents in the study took physical science as a subject. The mean mark was 39.85, the standard deviation was 7.13, the minimum mark was 24, the maximum mark was 52 and the median was 40.00.

38 respondents in the test took mathematics as a subject. The mean mark was 33.24, the standard deviation was 10.82, the minimum mark was 15.00, the maximum mark was 64.00 and the median was 32.50.

5.3 Analyses of association

The relationship between the dependent variables and the independent variables will now be reported and discussed firstly, by using univariate and then a multivariate analysis. There are two independent variables, namely science attitude and occupational sex-role stereotypes which are presented by continuous scores on two questionnaires (see chapter 4). The dependent variables are marks in biology, physical science and mathematics.

The table below gives the relationship between science attitude, job stereotypes and marks in biology as analysed by means of univariate analysis t-test.

Table 5: t-test for the relationship between Science Attitude, Job Stereotypes and marks in biology.

Variable	Standard Error	t-value	p-value
Science A	0.08749270	-0.72	0.4755
Job S	0.05913645	0.61	0.5445

The data shows that there is no significant relationship between science attitudes, job stereotyping and biology because both p-values are greater than 0.05. The null hypothesis is accepted.

The relationship between science attitude, job stereotypes and marks in physical science was analysed using univariate analysis t-test.

Table 6: t-test for the relationship between Science Attitudes, Job Stereotypes and marks in physical science.

Variable	Standard Error	t-value	p-value
Science A	0.11360291	0.92	0.3633
Job S	0.06035183	1.02	0.3161

The results show that there is no significant relationship between science attitude, job stereotypes and marks in physical science, because both p-values are greater than 0.05. The null hypothesis is accepted.

The relationship between science attitude, job stereotypes and scores in mathematics was analysed using univariate analysis t-test.

Table 7: t-test for the relationship between Science Attitudes, Job Stereotypes and marks in mathematics.

Variable	Standard Error	t-value	p-value
Science A	0.13757737	-0.97	0.3388
Job S	0.08695481	0.46	0.6458

The results indicates that there is no significant relationship between science attitudes, job stereotypes and marks in mathematics, because both p-values are greater than 0.05. The null hypothesis is accepted.

Because all three of these alternative hypotheses were rejected and the null hypotheses accepted, it was decided to analyse the independent variable, that is science attitudes and job stereotype, against science marks (which is the total of the three subjects: biology, physical science and mathematics). These results will now be reported.

Table 8: Descriptive statistics dependent variable science marks.

Variable	N	Mean	Std Dev	Minimum	Maximum	Median
Science marks	33	112.00	18.56	79.00	142.00	113.00

Out of 112 learners only 33 took all three subjects in grade 12. The mean mark was 112.00, the standard deviation was 18.56, the minimum mark was 79.00, the maximum mark was 142.00 and the median was 113.

The relationship between science attitude, job stereotypes and science marks was calculated and reported in table 9.

Table 9: The relationship between Science Attitude, Job Stereotypes and science marks.

Variable	Standard Error	t-value	p-value
Science A	0.29690875	0.78	0.4409
Job S	0.15899374	0.54	0.5923

The data show that there is no relationship between science attitude, job stereotypes and the total science marks in biology, physical science and mathematics. Both the p-values are greater than 0.05.

The results indicate that these learners did not perform well in all three subjects in grade 11. Although a longitudinal case study of the respondents was not carried out to track performance of these learners in science, the literature review suggests that gender differences in science achievement develop during secondary school years (see 3.2). Females in general do not perform equally well in science (especially in mathematics) when compared to their male counterparts (see 2.2.5). Despite the fact that this study did not compare the achievements of males and females in these subjects, the results show that Black females in the study did perform badly in science and in science subjects. This is in accordance with the results of other studies (see 2.2.8). Furthermore, studies indicate that matriculation results cannot be regarded as a true reflection of academic ability (see 3.2). Therefore it cannot be concluded that these female learners do not have an aptitude for science.

Research undertaken by Bernstein (2007: 37) revealed that in South Africa, in many cases, primary school teachers have a limited content knowledge of mathematics and science. This implies that students from the primary schools reach the secondary school level being inadequately prepared in these subjects. In addition, Woollacott and Henning (2004: 3) argue that the University of the Witwatersrand in South Africa is usually faced with the problem of under-preparedness of first year engineering entrants. These researchers view under-preparedness as a situation in which the knowledge and competencies of the student enrolling for an educational program relates negatively to the knowledge and competencies on which the program is based, which students are supposed to have acquired at the secondary school level. Therefore the student’s innate ability may be beset by inadequacies in knowledge, skills and academic expertise. These students are likely to achieve below their potential and will be unsuccessful even if they may have the ability to succeed.

The literature review undertaken documented that females in general have negative attitudes towards science (see 3.7). Added to negative attitudes towards science, females have been noted to hold stereotypical views of male dominated science careers (see 3.7.2). The results of the study show that the average for both science attitude and occupational sex-role stereotypes is slightly elevated. Polit and Beck (2008: 564) indicate that the median can be used to understand what the typical test score of a respondent is. Thus, when analysing the descriptive results it is evident that a typical student does not have a negative attitude towards science or hold stereotypes of jobs in this field. In this regard Halpern et al. (2007: 6) indicate that students' beliefs about their abilities are crucial determinants of their interest and performance in different subjects.

In light of the above discussion it is possible that the South African Government policies, guidelines and strategies that have been employed to increase enrolments of women in general and Black women in particular in science, are finally eradicating the problem of under-representation of Black females in SET, although academic achievement in science still poses a threat to these learners.

Because science attitude and job stereotype scores were moderate it appears that occupational sex-role stereotypes which are enforced by socialization processes (see 3.7.2) which females come across in society, might be diminishing.

5.4 Multivariate analyses

According to the statistical analyses plan (see Appendix C), each dependent variable was analysed using linear regression and analysis of covariance techniques. The confounding and independent variables are put into the model and variables with the least significant relation to the whole are removed one at a time.

5.4.1 Linear regression analyses

Table 10: Table Stepwise model of predictors of biology marks.

Model	**Independent variables in the model**	**Variable removed in the model**	**F-statistic for variable to be removed**	**Degrees of freedom**	**p-value**
1	Science A; job S; Age psycho; Ethnic	Job S	0.15	1.35	0.6983
2	Science A; Age; psych;	Ethnic	0.32	1.35	0.5758

	Ethnic				
3	Science A; Age; psycho	Science A	0.70	1.36	0.4086
4	Age; psycho	psycho	0.72	1.37	0.4009
Final	Age		2.17	1.38	0.1494

The results indicate that there is no significant relationship between job stereotypes, ethnicity, science attitudes, psychosocial factors and age, and marks in biology. The p-value is greater than 0.05.

Table 11: Table Stepwise model selection of predictors of physical science marks.

Model	**Independent variable in the model**	**Variable removed from the model**	**F-statistic for variables to be removed**	**Degrees of freedom**	**p-value**
1	Science A; job S; Age psycho; Ethnic	Age	0.88	1.24	0.3582
2	Science A; job S; psycho; Ethnic	Job S	2.26	1.24	0.1454

3	Science A; psycho; Ethnic	Science A	1.22	1.26	0.2799
4	Psycho; Ethnic	Psycho	1.50	1.27	0.2307
Final	Ethnic		2.82	1.28	0.1040

The results show that there is no significant relationship between age, job stereotypes, science attitudes, psychosocial factors and ethnicity, and marks in physical science. The p-value is greater than 0.05.

Table 12: Table Stepwise model selection of predictors of mathematics marks

Model	**Independent variable in the model**	**Variable removed from the model**	**F-statistic for variable to be removed**	**Degrees of freedom**	**p-value**
1	Science A; job S; Age psycho; Ethnic	Job S	0.52	1.28	0.4761
2	Science A; Age psycho; Ethnic	Science A	1.83	1.29	0.1862
3	Age psycho; Ethnic	Psycho	2.84	1.30	0.1021
4	Age; Ethnic	Ethnic	3.11	1.33	0.0875

Final	Age		9.13	1.13	0.0049★

The tables show that the relationship between the independent variable as well as the confounding variable and the dependent variable is not significant because all values, are greater than 0.05 which is the level of significance. There is therefore no significant relationship between job stereotypes, science attitudes, psychosocial factors and ethnicity, and marks in mathematics. There is, however, a significant relationship between age and marks in mathematics which will be discussed further on.

The following section provides the analyses of covariance of the dependent variable (biology) against the confounding variables (ethnicity, age and psycho-social factors).

5.4.2 Analyses of covariance of the dependent variable, biology, against the confounding variables, ethnicity, age and psycho-social factors.

Table 13(a): Relationship between marks in biology and ethnicity.

Variable	DF	F-Value	p-value
Ethnic	1 , 38	0.22	0.6393

The table shows that there is no significant relationship between marks in biology and ethnicity. The p-value is greater than 0.05.

Table 13(b): Relationship between marks in biology, age, and psychosocial background factors.

Variable	Regression co-efficient	t-value	p-value
Age	-1.13517915	-1.4	0.1690
Psychosocial	-0.46839080	-0.35	0.7300

factors			

The results show that there is no significant relationship between marks in biology and the confounders, age and psycho-social factors. Both p-values are greater than 0.05.

5.4.3 Analyses of covariance of physical science against ethnicity, age and psychosocial background factors.

Table 14(a): Relationship between marks in physical science and ethnicity.

Variable	DF	Mean square	t-value	p-value
Ethnicity	1 , 28	144.1500000	2.82	0.1040

The table shows that there is no relationship between marks in physical science and ethnicity. The p-value is greater than 0.05.

Table 14(b): Relationship between marks in physical science, age and psychosocial background factors.

Variable	Regression co-efficient	t-value	p-value
Age	-1.25711575	-1.43	0.1620
Psychosocial factors	1.57746479	1.03	0.3122

The table indicates that there is no significant relationship between marks in physical science and the confounding variables age and physical science.

5.4.4 Analyses of covariance of the dependent variable mathematics against the confounding variables, ethnicity, age and Psychosocial Background factors

Table 15(a): Relationship between marks in mathematics and ethnicity.

Variable	DF	F-Value	p-value

Ethnicity	1 , 32	1.24	0.2733

The results in the table show that there is no relationship between mathematics and ethnicity as a unit. The p-value is greater than 0.05.

Table 15(b): Relationship between marks in mathematics, age and psychosocial background factors.

Variable	Regression co-efficient	t-value	p-value
Age	-3.6814815	-3.21	0.0028★
Psychosocial factors	5.08879023	2.44	0.0198★

In the case of marks in biology and physical science, the confounding variables (ethnicity, age and psycho-social factors) did not have a significant effect on the dependent variable. However, regarding the dependent variable (marks in mathematics) both age and psycho-social factors have a significant effect, but ethnicity not. Table 15 (b) shows a negative t-value. Because the t-value is negative it means that the higher the age the lower the marks in mathematics. This indicates that the older the children are, the worse their performance in mathematics is. The reason could be that these learners might have repeated grades or they might have dropped out from school and returned or they might have attended school late as might be the case with students coming from farms. Students coming from farms might have to travel great distances to school and sometimes parents might keep their children at home until they are old enough to be able to travel those distances.

This might be the reason why the Department of Education in South Africa has provided transport for these learners, although recently they are being placed in hostels in nearby towns.

A high score in the psychosocial background factors is related to a high score in mathematics. A high score in the psychosocial background factors test indicates negative psychosocial background factors. However, in this study, learners with a negative psychosocial background have done better in mathematics. The reason for this is unknown. It could be a random result.

The author became interested to determine whether there was a significant difference between the science marks of the South Sotho females and that of the Xhosa females. This relationship was then investigated.

The relationship between science marks of South Sotho females and Xhosa females was analysed using a t-test.

Table 16: The t-test for the relationship between science marks of South Sotho and Xhosa females.

Variable: Ethnicity	Science Marks LS MEAN	Standard Error	t-value
S Sotho Xhosa	107.772042 120.555916	3.547670 5.028452	0.0480★

It is interesting to find that ethnicity was not a significant confounder because the P-value was greater than 0.05 (see Table 15 (a)). However, the t-test (Table 16) indicates that the performance of the Xhosa females in science was better than that of the South Sotho females. However, it is not known what causes the difference.

5.5 Summary

The chapter provided a discussion of the quantitative results of the study. Data were analysed using univariate and multivariate analyses. All hypotheses were rejected, but some interesting findings were highlighted. It was found that there was no significant relationship between science attitude and occupational sex-role stereotypes of rural Black females towards the natural sciences. These results were discussed with reference to previous research.

The statistical analyses of results also revealed that older females do not perform well in mathematics. Possible reasons which might account for the poor performance of older children in mathematics were highlighted. Another interesting finding was that the Xhosa females performed better in science than the South Sotho females. The researcher stated that the reasons for these differences were not known. Conclusions, recommendations and limitations to the study will now be discussed in the next chapter.

CHAPTER 6

CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

6.1 Introduction

The study has investigated factors that inhibit Black women from enrolling in SET careers in HE institutions. The fact that Black women are under-represented in SET careers and workplaces in South Africa, necessitated that the researcher explore the reasons for the under-representation, by engaging grade 12 Black females in the study. The rationale for engaging Black grade 12 females is that these learners will potentially further their educational aspirations at HE institutions.

In Chapter 2 a literature study that was undertaken revealed that Black women in South Africa are grossly under-represented in SET.

In Chapter 2 the interest and performance of Black women in SET was also explored. Black women were compared to women of other races worldwide, and to men and women of other races in South Africa.

In Chapter 3 a number of factors that might contribute to the under-representation of Black women in SET were explored. Particular attention was given to science attitudes and occupational sex-role stereotypes.

Chapter 4 provided a discussion of the research design and methodology employed in the study. The statistical analyses plan to measure the science attitudes and occupational sex-role stereotypes of rural Black females towards science studies in HE was provided.

In Chapter 5 research results were presented and discussed.

In this chapter conclusions will be drawn, recommendations provided and limitations of the study indicated.

6.2 Conclusions drawn from the study

6.2.1 Conclusions drawn from the literature study

The findings from the literature review suggest that on a global scale there is a general diminishing of interest among school learners and students in general in the study of science, engineering and technology. This diminishing interest can be observed from the secondary school level through to HE institutions (see 2.2.1). When comparing South Africa with the rest of the world regarding interest and performance in SET, it became evident that the SET sector in the country faces difficulties associated with human resources, as is the case internationally. It was also clear that the standard of mathematics and science teaching is far below than that of other countries (see 2.2.2). Despite the great numbers of Blacks in South Africa, many Black students still do not enrol in significant numbers in the SET fields of study. Many of them still enrol extensively in the Humanities at HE institutions (see 2.2.3).

When comparing the performance of males and females in mathematics and physical science in general in grade 12 between 2000 and 2006 in South Africa, the literature review suggests that the gender gap between males and females in participation and pass rates in these subjects is gradually closing (see 2.2.5). The SET fields of study and careers, however, seem to be still dominated by men in South Africa. Gender disparities are still noticeable because more men than women are found to occupy higher positions in the SET sector (see 2.2.5).

When the language proxy method was used to compare Black male and Black female pass rates by province in 2002 (see 2.2.7), it was found that Black males appear to perform better than Black females in all subjects across provinces in the country. Furthermore, it was found that in historically Black schools Black males appear to perform better in mathematics and science than Black females do, while on the contrary, Black females who attend former model C schools seem to perform better than Black females who attend school at historically Black schools in these subjects. Matriculation results and graduation rates in respect of both undergraduate and doctoral degrees attested that Black females, compared to females of other races in South Africa, are not doing equally well in these subjects at secondary school level and at certain programmes at HE institutions (see 2.2.8).

A number of factors, such as lack of role models, aptitude, self-confidence, attitudes towards science, occupational sex-role stereotypes, psychosocial background factors and many others have been associated with the under-representation of females in general in SET careers and workplaces (see 3.1-3.8). Research results authenticate that attitudes play an important role in occupational choices of adolescents. Children's attitudes towards SET careers are influenced by a variety of factors such as self-efficacy, interest and motivation. Gender stereotyping is found to be an explicit type of attitude towards science related fields according to which women should not choose scientific careers. These attitudes are formed because of experiences and societal beliefs about the expected roles of males and females (see 3.6). Some researchers have argued that very little research has been done regarding the under-representation of Black females in SET careers and workplaces in South Africa (see 2.1).

6.2.2 Conclusions drawn from the statistical analyses of research results

Research results revealed that Black women in this study have less (although not significantly so) negative attitudes towards science and do not hold as many (although not significantly so) stereotypical views of male dominated science occupations as has been proven in other studies (see 3.8). In the researcher's view the South African government policies, guidelines and strategies which are used to create awareness that everybody can participate in the natural sciences are gradually becoming more effective. One can speculate that Black female learners have come to realise that they can also participate in the natural sciences, and as South African citizens, they are also expected to contribute to the scientific knowledge of the country.

It is also important to note that, although the literature review strongly suggests that negative psychosocial factors are related to poor academic achievement, the results in this study have proved otherwise. Reasons for these findings are not known. It could appear that learners with more or less similar psychosocial backgrounds in rural areas seem to be at ease with their background situations, with the result that their background factors do not have any significant or minimal effects on their achievements (see 5.4.4).

Another interesting fact to note was that older learners tend to perform poorly in mathematics when compared to younger learners. The reasons for these results are also not known. In some cases in the rural areas older children have to take care of the other younger children and grandparents, either because the parents have sought jobs in urban areas or parents have died because of HIV and Aids related diseases. These conditions place a lot of stress on these female learners with the result that they might have repeated grades and might have experienced low academic achievement in subjects such as mathematics in particular.

It was also found that there were differences in the academic achievements in science of South Sotho females when compared to the academic achievements in science of Xhosa females. The reasons for these differences in science achievements are not known. However, studies conducted in the USA have shown that there are different participation and achievement rates in SET among females of different ethnic origins. The researcher has not come across studies comparing the participation rates and achievement of Black females of different ethnic groups in science in South Africa.

Most importantly, it was found that even if the research results of the present study suggest that science attitudes might have improved slightly and occupational sex-role stereotypes might have decreased, academic achievement in science is still poor. The reasons for the poor achievement in science might be attributed to a lack of motivation to study science. Debacker and Nelson (2000: 245) view motivation to learn as a crucial factor in science education because motivation is linked to "…cognitive engagement and conceptual change". These researchers indicate that decisions to engage in meaningful learning may be influenced by individual learners' motivation, goals for performing the activity, beliefs about their capabilities, the type of task and how important they perceive the task to be. Taylor and Sweetnam (2000: 34) feel that academic achievement of females in the natural sciences, especially in mathematics and physical science, might also be influenced by the science content which appears to be detached from the females' experiences.

Concerning science stereotypic beliefs, Debacker and Nelson (2000: 253) found in their study conducted in America, that adolescent females' scores were lower than those of adolescent males regarding science stereotypes. These researchers argue that although females contested blunt statements of stereotypical beliefs they may still be affected by cultural stereotypes on a less conscious level. This might be the reason why they do not perform well in mathematics and physical science in particular. The same might be true of the females in the present study.

The fact that only 33 females out of 112 took biology, physical science as well as mathematics as subjects at secondary school level suggests that the other females might lack self-confidence and they might also have low self-efficacy and therefore lack interest in mathematics and mathematics related courses (see 3.8.1). Research indicates that students with low self-efficacy are not intrinsically motivated to study science. These numbers suggest that the grade 12 females in the study are still skeptical of following the SET careers and fields of study in higher education institutions because most of them have rather opted for mathematics literacy and other subjects.

In light of the above discussion a number of recommendations are put forward.

6.3 Recommendations

The statistical analyses in this study necessitated the acceptance of all the null hypotheses. Black females might have slightly better attitudes towards the natural sciences and slightly better occupational sex-role stereotypes. However, the average performance of the Black female learners in biology, physical science and mathematics supplied to this study was poor.

It is recommended that educators, parents, curriculum planners, the government and all stakeholders in the education system, continue to encourage participation of Black females in the natural sciences. Since science attitudes may be in the process of changing positively and occupational stereotypes might have become less, more emphasis should be placed on assisting Black females to perform better in science and mathematics. This task is largely dependent on educators teaching these subjects at the primary level as well as the secondary school level. Halpern et al. (2007: 12-46) encourage educators to:

- *Teach students that academic abilities are expandable and improvable*

Halpern et al. (2007: 12-13) purports that learners can be taught that mathematics and science abilities, like all other abilities, can be developed with regular attempts and learning. These researchers indicate that studies have shown that learners with ability, but who view their cognitive abilities as predetermined and constant, are more likely to encounter greater disappointments and lower performance and eventually reduce their attempts when confronted with difficulties. On the other hand, learners who perceive their abilities as expandable tend to keep trying amidst of the frustrations they might encounter in order to enhance their performance in mathematics and science.

- *Provide prescriptive, informational feedback*

Prescriptive, informational feedback concentrates on strategies, effort and the process of learning. According to Halpern et al. (2007: 15-17), the recommendation exclusively pursues feedback that aims at learners' awareness of their beliefs about why they did or did not achieve on a particular task. This boosts students' beliefs about their capabilities in biology, mathematics and physical science. Educators are encouraged to design classroom settings in which learning, improving and understanding are stressed. Educators can also highlight learners' efforts and strategies when explaining examination marks or assignments scores, but should guard against providing praise on simple tasks because this can undercut learners' motivation.

Debacker and Nelson (2000: 255) argue that by emphasising strategy and effort educators enhance a sense of control in learners' own learning. These researchers indicate that this sense of control is specifically helpful for learners who grapple with their schoolwork and who are at the verge of developing the sense that they are helpless when confronted with academic failure. This sense of control is intensified when learners acquire the habit of observing their own progress of learning and ascribing "…progress to effortful use of effective learning strategies".

- *Create a classroom environment that sparks initial curiosity and fosters long-term interest in mathematics and science*

Educators are encouraged to implant mathematical word problems and science activities in interesting contexts. This helps learners to become aware that science is related to their everyday lives. Reading activities should be implanted into the context of science inquiry, where possible, in order to foster situational relevance and further interest (Halpern et al. 2007: 23-25).

- *Provide spatial skills training*

Research has indicated that spatial abilities which are related to performance in mathematics can be learnt and improved with practice on specific tasks. Educators can teach these skills by encouraging girls, at a very young age, to play with toys that entail spatial knowledge, such as building toys. Older children can be taught to mentally imagine and draw mathematics or other assignments so that they can come to terms with spatially demonstrated information. Educators also have to provide opportunities in spatial skills such as mental rotation of images (Halpern et al. 2007: 27).

- *Help learners to structure appropriate study habits and to develop an identity as a learner*

Wlodkowski (2000: 3-4 of 4) encourages educators to assist learners to find a way of acquiring frequent study habits and make this a daily exercise. In this way learning becomes more habitual and interesting. In addition, learners could be assisted in developing an identity as learners. This researcher believes that identity is a strong motivational force. Learners should indicate to themselves who they are and what is it they require from themselves. This type of motivation can help them do better in their learning programs. Mackenzie (2002: 168) indicates that at HE institutions a 'deep learning approach' is required if students are to succeed in mathematics and science related fields. When students use this approach they become highly motivated and interested in the subject and perceive the subject to be relevant, personally or vocationally. If this is the case, secondary school female learners can also be taught to acquire this skill so that when they reach the HE institutions they are already fully prepared to study at these institutions.

- *Engage students in laboratory work in university chemistry*

Reid and Shah (2007: 173) view laboratory work as the most important element in science education at all levels. It is assumed that experimental work is a fundamental part of any science course which allows learners to do practical work. If females view science as detached from their daily experiences then practical work might enable females to see connections in the natural sciences, in particular chemistry, with the real world. Reid and Shah (2007: 177) also emphasize that the development of the ability to make observations, measurements, predictions, interpretations and to design experiments, depends on practical work. Although these researchers emphasize the need for laboratory work at universities they strongly argue that laboratory work in HE should not be seen in isolation, it must be followed by school laboratory experiences. The implication is that when learners enter HE science studies they might be better prepared to engage with the sciences and eliminate the problems of under-preparedness as reported by some researchers (see 5.3). In this regard the South African government has to make serious commitment to provide laboratory experiences for school learners.

- *Increase parental involvement*

Parental involvement and encouragement is of utmost importance to female students in particular. Parents should ensure that time is set aside to allow girls to study at home. Household chores should be distributed equally among boys and girls. Even if parents themselves are not able to help their children with schoolwork they will be able to provide children with opportunities to study at home. Parents should know their children's educators and discuss the progress of their children and seek advice from educators on how to assist their children to enhance achievement.

- *Implement Teachers Mentorship Programmes (TMP)*

Horacke and Fricke (2004) believe that many educators do not have the ability to identify where learners have a poor foundation, and teaching is done without addressing the basics. These researchers believe that the TMP should be provided to biology, mathematics and physical science educators in disadvantaged schools during school hours by experienced mentor educators. To make significant improvements in the teaching and learning of biology, mathematics and physical science, regular structured extra lessons should be given for a number of years at schools. These remedial lessons should be given up to grade 12 until educators themselves are empowered to address the backlog of learners in general in these subjects. Remedial lessons will minimize problems of under-preparedness in science and mathematics when learners enter the natural sciences programs at HE institutions.

Fortunately the South African Department of Education has introduced a policy on Foundations for Learning, RSA DoE (2008: 1-23), whereby a certain program has to be followed in primary schools to address the backlog in mathematics and the Language of Learning and Teaching (LOLT) up to grade 6 level. The program aims at improving mathematics and LOLT skills in primary schools.

- *Prepare secondary school learners for HE*

Studies have shown that many learners who pass the National Senior Certificate are not yet ready to succeed at HE institutions in biology, mathematics and physical science in South Africa (see 5.3). Addressing the Challenges Facing American Undergraduate Education (2006: 5), suggests that the secondary school curriculum should be structured in such a way that graduation requirements of the HE institutions' standards are met. The American Council on Education, together with other organizations, has embarked on the National Diploma Project, which is a state initiative, to increase the number of secondary school learners who leave secondary school, ready to engage with HE institution mathematics and science programs without a need for remediation. HE institutions are encouraged to work with secondary schools to address transition problems. According to this research, remediation is only useful if it deals with small scale inadequacies. Furthermore remediation is inadequate if it has to address national academic unpreparedness of learners in mathematics and science.

- *Implement measures to improve educator qualifications in biology, physical science and mathematics*

Research has shown that often educators (especially primary school educators) are not adequately trained to teach biology, mathematics and physical science (see 5.3). If this is the case, educators teaching biology, mathematics and science should be encouraged to improve their qualifications in order to master the content knowledge of these subjects. Because the researcher is an educator at a primary school it was observed that educators need a great deal of guidance in implementing programs such as the Foundations for Learning. Regular in-service training should be provided to primary school educators to ensure significant improvements in the learners' grasp and mastering of mathematics and LOLT. In addition bursaries should be awarded to all educators who have not been adequately trained to teach these subjects, with special emphasis on primary school educators. In the researcher's opinion the programmes and policies which are aimed at improving the teaching and learning of biology, mathematics and physical science will not be implemented with maximum success if educators themselves lack the content knowledge of these subjects.

In conclusion, recommendations are also provided that are based on the findings of the present research results. While acknowledging initiatives that the democratic government of South Africa has put forward to promote access of women in general to SET careers of study and workplaces, it became evident from the results that some significant gains might have been produced in minimising occupational sex-role stereotypes in Black female learners with regard to male dominated scientific careers. It can de deduced that a decrease in stereotypes resulted in these Black females' science attitude changing positively, although their performance in science is not good. Therefore the government should embark on strategies that could help these learners to achieve in science and mathematics classrooms. Because educators spend much time with students it is hoped that they will also change their attitudes toward females in science (see 3.6.2.1) and strive to help these females to find a place in the scientific arena by ensuring that they perform optimally. All stakeholders should reinforce their efforts in helping Black females to achieve in mathematics and science to enable them to claim their rights as other women of different races in South Africa and globally do, because "… lack of achievement in mathematics at school can be a barrier to entry into HE" (Mackenzie 2002: 168).

6.4 Limitations

The sample under study was relatively small (n=112) and out of the 112 participants only 33 took all three subjects namely biology, physical science and mathematics as subjects at grade 12 level. Only Black female learners from 5 schools in the Xhariep district, in the Southern Free State took part in the study. Sampling was done based on proximity of the schools. This study was limited because it did not explore and compare the science attitudes and the occupational sex-role stereotypes of Black females to that of Black males. Because random sampling was not done, these results cannot be generalised to the Southern Free State rural Black females, but they can possibly be used to affect the mindsets of educators and curriculum planners to view Black females as also being interested in science but possibly being discouraged to follow SET studies and careers because of poor performance in school mathematics and science.

Using self-report inventories, as was the case in this study, set an arguable limitation to the study. In such inventories participants might only give censored or biased information. In practice however this rarely happens since the Alpha Cronbach of the measuring instruments was high.

6.5 Further research

The literature study undertaken showed that little research has been conducted on factors inhibiting Black females from following careers in SET (See 2.1), it is suggested that further research be undertaken to:

- Explore the attitudes and occupational sex-role stereotypes of Black females in rural areas towards natural science studies in HE with much larger samples.
- Compare the attitudes and occupational sex-role stereotypes of both Black rural male and female students towards natural science studies in HE with a much larger sample.

6.6 Conclusion

The significance of the research is that the science attitude and occupational sex-role stereotypes of rural Black females were investigated and analysed. By this means information regarding the problem of under-representation of females' entrance into natural science studies in HE was investigated. The research results could shed light on the possible reasons why females do not enrol in great numbers in science and mathematics at secondary school level as well as in the SET fields of study at HE institutions. Such knowledge could ultimately pave the way for measures by means of which the problems could be appropriately addressed. Possible hypotheses for further study can be formulated from the study thus promoting more research in this area.

Furthermore, the rationale for embarking onto such a challenging study has personal significance. The personal significance of the study is that, the researcher's own position as a primary school natural science and technology educator in the rural areas of the Xhariep district has put the researcher in an excellent position to undertake the study, understand the situation and strive for improving female performance in the natural sciences and technology as subjects at primary school level. Studies have shown that science attitudes and sex-role stereotypes are formed as early as primary school (see 3.6.1).

It is hoped that these recommendations will be used by the government, education officials and the parents in order to help Black females to achieve in science at secondary school level. It is also hoped that, these efforts might increase the participation of Black females in the natural sciences, and particularly in the SET fields of study, at HE institutions and in workplaces. The Department of Science and Technology (RSA DST 1998: 44) emphasizes that

"… Scientific achievement builds national pride. A nation without a core of scientific competence will in the end be held to ransom by foreigners. Because scientific research fulfills a fundamental need, a nation will loose gifted people and their contributions when science is neglected. Neglecting science is in the end the recipe for mental and material poverty".

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APPENDIX: A

QUESTIONNAIRE

THE ATTITUDES AND OCCUPATIONAL SEX-ROLE STEREOTYPES RELATING TO NATURAL SCIENCE STUDIES

INSTRUCTIONS
Read the questions carefully.
Please indicate your response by making an 'X' at the appropriate block.

SECTION A: BIOGRAPHIC INFORMATION

1-13

Student number													

2. Age of respondent

FOR OFFICE USE ONLY

14

Age	

3. Language

15

Language	
South Sotho	1
Xhosa	2
Tswana	3
Other	4

4. Marks

16

Marks in Biology	June 2008	November 2008	Total Average

5. Marks

17

Marks in Physical Science	June 2008	November 2008	Total Average

6. Marks

18

Marks in Mathematics	June 2008	November 2008	Total Average

OVERVIEW OF THE THESIS

Chapter 1

This introductory chapter provides an orientation and background of the study as well as a brief outline of the quantitative research methodology employed.

Chapter 2

The second chapter provides a literature study regarding the representation of Black women in science, engineering and technology (SET). This chapter highlights specific statistics indicating that women in general, and Black women in particular, are grossly under-represented in the SET fields of study and careers.

Chapter 3

This chapter highlights factors that influence vocational choices of Black girls. A variety of factors such as cognitive and non-cognitive factors are highlighted. This chapter will also highlight that the literature review consulted, indicates that although much international research has been undertaken in this regard, there seems to be a few empirical studies within the South African context.

Chapter 4

Chapter four provides the implementation of the research. This chapter highlights the background to the research rationale by stating the research problem and the hypotheses. The aims and objectives of the study are provided and the dependent, independent and confounding variables are identified and operationally defined. Data collection techniques and analyses are provided in which a univariate and a multivariate analyses are employed. The objectives of the statistical analyses are highlighted. The chapter also informs the readers about the reliability and validity of the research results.

Chapter 5

In the fifth chapter the findings of the results are reported and discussed. Descriptive analyses of confounding, independent and dependent variables are provided. Analyses of association are highlighted in which a univariate and a multivariate analysis are provided. The chapter concludes with a discussion and a summary of the quantitative research results.

Chapter 6

The last chapter provides a summary of data and draws conclusions, makes recommendations and indicates the limitations of the study. Conclusions drawn from the literature study and from the statistical analyses of the research results are highlighted. Recommendations which could be employed by the South African government and the Education Department are suggested. The chapter closes with the limitations of the study and conclusions.

CHAPTER 1

ORIENTATION AND BACKGROUND OF THE STUDY

1.1 Introduction

The history of South Africa shows that little attention has been paid to human resource development in the science, engineering and technology (SET) fields. Women had to suffer exclusion from educational resources. In addition to racial stereotypes are the stereotypes about women in science (Mabandla 1998: 32). According to these stereotypes women are perceived as unable to engage in the SET fields of study. As a result women are not sufficiently engaged in the SET occupational fields in South Africa. Linked to this situation is the fact that Black women are even less engaged in these types of occupations (Facing the Future 2006: 2 of 3). Mangena (2005: 3 of 4) indicates that 90% of the population in South Africa is made up of Blacks, and yet they make up only 2% of South Africa's scientific population. He further argues that the rate at which young people, especially Blacks, women and the disabled engage in the SET is distressingly low.

The same situation exists regarding higher education (HE) studies for women in general, and Black women in particular. The Department of Science and Technology (DST), (RSA DST 2004: 28) documents that there are disparities in the SET participation of women in different race groups, especially at the doctoral level, in South Africa. In 2001 65% of all female doctoral enrolments and 76% of all female doctoral graduates in the university sector were White women. African males' total doctoral enrolments and graduations were at 31% and 25% respectively, while Black females' doctoral enrolments and graduations were at 21% and 15% respectively.

When one examines the pass rates in mathematics and science as school subjects, the same picture appears. Data supplied by the Edusource Data News (2003: 23-24), show that the number of female candidates enrolled for and passing physical science and mathematics in South Africa in grade 12, is a matter of concern. This data indicate that in 2002 there was a better performance in physical science higher grade (HG) by Indian and White females. Indian and White females' physical science HG enrolments were at 50.7% and 43.0% respectively, while the percentage of passes was at 75.4% and 87.7% respectively. When looking at the enrolments of Black males and Black females in the same subject at HG, enrolments were at 55.8% and 44.2% respectively. Although there were no significant differences between White and Black female enrolments in physical science HG, Blacks were the poorest performing – only 19.9% of females and 26.6% of males passed. In mathematics HG the Indian females' enrolment was at 52.9% while the pass rate was at 72.3%. For White females the enrolment was at 50% while the pass rate was 88.9%. Black males accounted for 57.3% of enrolment while the pass rate was 31.1%. Black females' enrolments were at 42.7% while the pass rate was a discouraging 28.8%.

However, this is not only a problem in South Africa, it is a worldwide problem. Many researchers attribute this under representation of females in SET in general to a variety of factors. These factors include lack of parental guidance in career choices (Geldenhuys & De Lange 2007: 129), classroom experiences (different treatment of females by both male and female educators) and the 'superwoman' image of science which does not make science a very appealing option for young women, in that the 'superwoman' image suggests that those women who pursue science must be exceptionally gifted compared to ordinary women (Reddy 1998: 94); ethnic origin (parents in some communities have a powerful influence on their children's career choices) (Lightfoot 2006: 1 of 3), and socio-economic factors (Ferry 2006: 3 of 6) to cite but a few.

A number of studies document that school learners and students in general show little interest and are reluctant to choose science subjects, especially physical science and mathematics, towards the end of their secondary school years and at post secondary levels (Koballa 2008: 1 of 3). Russell and Peacock (2005: 24) indicate that females are less interested in science than males are. In confirmation Trumper (2006: 47) is convinced that the drop in science enrolments will have crucial consequences for the scientific literature of the forthcoming generations. Therefore the development of positive attitudes towards science, scientists and learning science, which is a component of science education, is increasingly becoming a matter of importance. As a result Koballa (2008: 1 of 3) indicates that investigation into science related attitudes is receiving greater attention than before. Trumper (2006: 47) discerns that a number of science educators attach great value to the affective domain in the choice of a career and that the affective domain is symbolised by a number of concepts such as attitudes, preferences and interests. This may lead to a possible conclusion that the problem lies within the study field of *attitude* and in particular *science attitude.* There are many definitions of attitude. Baron and Bryne (1991: 137 & 138) refer to attitudes "… as general evaluations people make about themselves, other persons, objects or issues. Attitudes reflect past experiences, shape ongoing behaviour and serve essential functions for those who hold them".

Baron and Bryne (1993: 138) further indicate that attitude involves the belief that stereotypes have an influence on people's attitudes. Brownlow, Jacobi and Rogers (2000: 119) believe that women's avoidance of science includes impressions of the gender correctness of the SET field. As a result females may have negative views about their abilities in SET. This gender appropriateness of careers could be due to families which usually shape females' beliefs about their abilities and career preferences, what parents expect from the different sexes, the educational structure, mass media and culture (Osiruemu 2007: 106). In addition, Prykhodko (2006: 26) argues that science with its firm structural hierarchies denies females many opportunities to engage in career development. Prykhodko (2006: 26) further claims that gender-based dominance and preconceived notions about who should do science, lead to a feeling of uncertainty, and women's aspirations to secure a place in the hierarchy, even if it could be at a low level, are doomed. This in turn endorses further rigidisation of the social composition within science.

Gender stereotyping contributes to women's attitude towards science. Females in general have fallen prey to gender stereotyping according to which females are not supposed to fill certain occupations. This is even more so for Black people who have to contend with racial stereotypes according to which Black people do not have the aptitude or interest to pursue science (Mabandla 1998: 32).

1.2 Statement of the research problem

The research problem in this study centres on the problem of under-representation of Black females in SET and most often, lower achievement of these females in most instances. Many factors might possibly contribute to the situation, including sex-role stereotypes and females' attitudes regarding the natural sciences (see 3.6). In South Africa, factors contributing to the under-representation are not well known and not extensively researched, in particular in rural areas. In the light of this the general research question that gave rise to this research can be stated as follows:

Is there a relationship between science attitude and occupational sex-role stereotypes among rural Black females and the entrance into natural sciences studies in Higher Education?

The criterion for entrance into natural science studies will be the marks of grade 12 rural Black females obtained in the subjects: biology, physical science and mathematics, combined with the results obtained from Entrance Tests in many HE institutions as stipulated by Higher Education South Africa (HESA). Therefore the specific research question is as follows:

Is there a relationship between science attitude and occupational sex-role stereotypes among rural black females and marks in biology, physical science and mathematics?

1.3 Aims and objectives of the research

The aim of the study was to investigate the relationship between science attitude and occupational sex-role stereotypes relating to natural science studies in higher education among rural Black females, by engaging in the following objectives:

- Undertaking a literature study regarding the research topic by consulting books, government publications, papers, internet articles, dissertations and journals.
- The measuring of science attitudes and interests of Black girls regarding the natural sciences by using valid and reliable instruments.
- The measuring of occupational sex-role stereotypes of Black girls regarding the natural sciences by using a reliable and valid questionnaire.

1.4 Demarcation of the research

This study falls within the discipline of education with HE studies as related interdisciplinary field, with a specific focus on entry into HE. Lack of achievement and enrolments of certain subjects at school level can be a barrier to entry into HE. Further investigations of attitudes and stereotypes towards the SET fields informed the debates within HE regarding how to enhance teaching and learning of the natural sciences at primary school and secondary school levels. The research focused on the grade 12 Black females in 5 secondary schools in the rural areas of the Xhariep district in the Southern part of the Free State province of South Africa.

1.5 Clarification of concepts

The following section informs and clarifies the concepts that form the basis of the study.

1.5.1 Science Studies

The natural sciences, as referred to in the general sense (in this study) are seen as a broad field of study that may cover all aspects of teaching and learning in the following subject fields: Physics, Biology (Life Sciences according to the National Curriculum Statement (NCS), Mathematics, Chemistry, Physical Science, Zoology, Botany, Geology, Geography, Computer Science, Technology and Agricultural Science.

The natural science subjects included in the empirical study focus on biology, physical science and mathematics as grade 12 school subjects.

1.5.2 Science Attitudes

According to Allport (in Howarth 2006: 7) an attitude is "… a mental or neural state of readiness, organised through experience, exerting a directive or dynamic influence upon the individual's response to all objects and situations with which it is related" Trumper (2006: 48) refers to science attitudes as being shaped by interests in science. Therefore interest is a high specific form of an attitude.

1.5.3 Occupational Sex-role Stereotypes

Occupational sex-role stereotypes are a system of values concerning which sex should perform certain jobs (Miller & Hayward 2006: 70).

1.5.4 Black

The term “Black” is occasionally used to refer collectively to African, Coloured and Asian people (RSA DST 2004: 6). For the purpose of this study the term “Black” refers to the African component of the population groupings in South Africa.

1.6 Method of research

1.6.1 Research design

A quantitative design was regarded mostly suitable for this study because of the level of objectivity that can be obtained, the possibility of generalization, the inclusion of a larger sample and the control for bias through design (McMillan & Shumacher 1993: 14-15).
A non experimental research inferential multivariate research design in the form of a survey was employed. A non experimental research design gives a description of something that has occurred, or investigates relationships between things without suggesting cause-and-effect relationships (McMillan & Schumacher 1993: 34). This investigation could establish whether there is a relationship between science attitudes and occupational sex-role stereotypes and marks in biology, physical science and mathematics.

1.6.2 The test group

The target population of the investigation was all grade 12 rural Black females in the Xhariep district in the Southern part of the Free State province of South Africa.

1.6.3 Data collection, analysis and reporting

Data were collected using a questionnaire encompassing two instruments measuring science attitudes and occupational sex-role stereotypes to elicit reactions, beliefs and attitudes. From these instruments the dependent, independent and confounding variables were extracted. The dependent variable consisted of the grade 12 females' marks in biology, physical science and mathematics. The independent variables in the study were science attitudes and occupational sex-role stereotypes. The confounding variables were ethnicity, age and psychosocial background factors. Data were analysed by the department of Computer Service at the University of the Free State. Results were then reported using tables.

1.6.4 Ethical considerations

Informed consent was obtained from the University of the Free State, the Department of Education, the principals of schools where the survey was done and the grade 12 female students (Appendix B). Participation in the study was voluntary and did not interfere with the schools' daily programme. The consent forms were read and discussed with the participants. The purpose of the study was communicated to the participants. It was then explained why they were being requested to participate in the study. The participants were given an opportunity to ask questions in order to clarify any misunderstandings regarding the purpose of the study. The researcher requested the school principals to make one educator available in order to bear testimony to the fact that no learner was forced into participating in the study. After reading through the consent forms, learners who were willing to participate in the study were requested to sign the consent forms. The educator, who was present when the consent forms were discussed, was requested to sign the consent forms of all learners who were willing to participate in the study as a witness that participation was voluntary. Anonymity of research results was assured. The researcher further explained that data would not be linked to individual subjects by names or by schools. The participants were then requested to respond to the questionnaires. These measures ensured that the study became ethically sound.

1.6.5 Reliability and validity of the research

McMillan and Schumacher (1993: 227) refer to reliability as the stability of measurement, the extent to which similar results are obtained over diverse forms of the same instrument or instances of data collection. Because the questionnaires and scales which were used in the study have proven reliability, the reliability of the study can be assumed.

Validity according to Golafshani (2003: 599), establishes whether the research actually measures what it was planned to measure or how accurate the results are. Internal validity was obtained because extraneous variables were accounted and measured for as far as possible (Maas 1998: 24). External validity cannot be claimed because random sampling was not done. Therefore research results cannot be generalized to the population from which the sample was drawn (Kellinger 1986: 300).

1.7 Conclusion

The educational background and context under which this study takes place has been presented. The next chapter presents a review of the representation and performance of Black South African females in SET fields of study and careers.

CHAPTER 2

THE REPRESENTATION AND PERFORMANCE OF BLACK WOMEN IN SCIENCE, ENGINEERING AND TECHNOLOGY: COMPARATIVE PERSPECTIVES

2.1 Introduction

The research data on the representation of women in science, engineering and Technology, (SET) are very interweaved. In different kinds of studies the position of Black women in science is compared to that of men, other races and Whites. As a result it becomes difficult to compare these studies. Reference is made to a number of secondary sources because the information was important and the original sources could not be found. The types of resources consulted included books, internet articles, journals, papers, reports, unpublished dissertations and government publications.

The literature review of South African origin covers both mathematics and physical science as subjects offered in the higher grade (HG) and the standard grade (SG) in grade 12 according to the old curriculum. When the senior certificate was replaced by the national senior certificate in 2008, mathematics became compulsory while physical science remained an elective subject (Bernstein 2007: 31). Learners were required to write either mathematics or mathematics literacy. Furthermore, the differentiation between SG and HG was phased out.

According to Moletsane and Reddy (2008: 13) even though there is substantial literature regarding the engagement of women in SET a large part of it comes from the developed countries. Moletsane and Reddy (2008: 13), citing research conducted by Campion and Shrum (2004), believe that empirical studies exploring the effects of gender representation in SET are limited. Therefore it is difficult to determine the influence of gender on SET in the South African context because of the scarcity of literature in this area of interest (Moletsane & Reddy 2008: 9). The Centre for Research on Science and Technology (CREST 2005: 15), referring to studies conducted by Oldham, (2000) confirms that this is a global problem since what many countries appear to have in common is "…the lack of reliable, comprehensive and comparable sex-disaggregated data which is critical in enabling policy makers and planners to assess the status and profile of women in SET".

The aim of this chapter is to give a picture of the current situation of Black South African females in SET fields of study and careers as seen against the background of international studies on these aspects. As such the following questions direct the literature review:

- Is the position of Black women in SET in South Africa the same as or different from that of Black women in other countries?
- How does the position of Black women compare with the position of Black men in South Africa? and
- How does the position of Black women compare with the position of White women in South Africa and worldwide?

2.2 Comparative perspectives on the interest and performance of Black females in SET in South Africa

In this section, a comparison will be made between relevant findings and perspectives from literature which involves gender and racial differences as well as possible national/international variations. As far as possible, perspectives will include the school sector, higher education and career information. The discussion commences with perspectives on the diminishing interest in SET worldwide.

2.2.1 Diminishing interest in SET worldwide

Globally, there have been debates about the lack of interest of students in general in careers in the SET fields. Babco and Golladay (2001: 19 of 96 & 27 of 96), Frehill, Ketcham & Jeser-Cannavale (2005: 34) and Loya (2000: 27) document that the science and technology (S & T) workforce in the United

States is growing old and that enrolments of students in the USA, have been declining for several years in these fields, especially in physical science, mathematical sciences, engineering and computer science, while dramatic increases have been noted in the biosciences and health fields.

As such, during the late 1980s the National Science Foundation (NSF) projected a “looming shortfall” of scientists and engineers towards the end of the 1990s in the USA (Teitelbaum 2001: 72 of 96). What is disturbing, according to Chubin and Pearson (2001:12 of 96), is that the need for a science and engineering workforce is anticipated to escalate three times more quickly than other professions. According to Gatta and Trigg (2001: 2), there is a dire need for computer scientists, engineers as well as programmers in the United States. As a result, there are about 190 000 vacancies in Information Technology, and there is a likelihood that this figure will increase, producing about 5.3 million new jobs to be filled by the year 2008.

In many countries, after spending a number of years in secondary science education, many students do not continue to study science at higher levels and most dislike the subject (Gough 2007: 27). According to Trumper (2006: 49), in Israel less than 25% of students in secondary schools major in science and there is a significant drop in enrolment figures as compared to those in the 1980s because about half of the senior students did not enrol for the sciences in that country. Trumper (2006: 49), citing studies conducted by Osborne et al. (2003), mentions that in England and Wales enrolments of science students dropped by more than 50%, from the 1980s to the beginning of the 2000s. In Nigeria, although the number of institutions that present engineering programs has multiplied dramatically, the standard of engineering education has deteriorated radically due to dwindling interest in SET among school leavers (Kofoworola 2004: 23).

The findings from this literature review suggest that on a global scale there is a general diminishing of interest among school learners and students in general in the study of science, engineering and technology. This diminishing interest can be observed from the secondary school level through to higher education institutions. If this trend continues the implication is that the world will not be able to meet the challenges of the new scientific and technological era with the small scientific workforce pool available.

2.2.2 Comparison of South Africa with the rest of the world regarding interest and performance in SET

The Department of Science and Technology, (RSA DST 2006: 6) argues that South Africa is challenged by low participation of students in SET, and a dwindling scientific research population. As a result, Women in Science (2003-2007: 1) citing research done by Lawless (2005), indicates that there is a dearth of substantially proficient men and women in specialised SET fields. According to the Facing the Facts study (RSA DST 2004: 6), South Africa's future SET workforce will be drawn from the small pool of doctoral students in technikons and universities. De Jager (2000: 19) indicates that in most SET faculties the number of technologists is anticipated to grow only at a rate of 10% which must not only meet the demands of the developing economy but must be able to compete globally. The sad news is that the number of engineering candidates is plummeting across South Africa and graduation rates are also not promising (Jawitz 2000: 17). South Africa finds itself in the same dilemma as other countries in the world regarding interest and performance in SET.

Because the acquisition of science and mathematics skills has become a worldwide concern, South Africa participated in Trends in International Mathematics and Science Studies (TIMSS). TIMSS seeks to compare the performance of American learners in mathematics and science to that of learners in other countries (Bernstein 2007: 33). Results from TIMSS collected in 1995, 1999 and 2003 document that South African learners were performing badly in mathematics and science when compared to learners in other countries. In 2003, 45 countries participated in a TIMSS survey and South Africa was ranked last (Bernstein 2007: 34). These countries included African countries such as Botswana, Tunisia, Egypt, Morocco and Ghana.

Commenting on these results, Hofmeyr (2006: 6) acknowledges the crisis in mathematics and science education in South Africa.

A closer examination of the Xhariep district grade 12 mathematics and science statistics in 2006 in the Southern Free State indicates that out of the 22 secondary schools, there were 21 entries in mathematics HG with 17 passes, and out of 273 SG entries, 193 candidates passed. In physical science HG there were 48 entries and 29 candidates passed, while for SG there were 185 entries and 140 candidates passed. The statistics, however, do not indicate the overall number of learners who sat for the grade 12 examinations in 2006 in the Xhariep district (RSA FSDoE 2006: 1 of 19). These statistics (although data are not available for 2007 and 2008) are an indication of inadequate preparation of the Xhariep district population in mathematics and science HG, which according to Smith (2007: 2 of 14), is a requirement for entry into SET fields of study. When looking at the other scientific domains such as the life sciences and physical sciences, it is found that in 2001 women comprised the majority of doctoral enrolments in these domains (RSA DST 2004: 19).

When comparing South Africa with the rest of the world regarding interest and performance in SET, it becomes evident that the SET sector in the country faces difficulties associated with human resources, as is the case internationally. It is also clear that the standard of mathematics and science teaching is far below that of other countries. This could be the reason why the performance of South Africa's learners has been well below standard, as indicated by the TIMSS results, compared to the performance of learners in other countries.

2.2.3 Interest and/or performance in SET of Blacks and Whites in South Africa

In South Africa enrolments for mathematics and science learners in grade 12 have been decreasing over a number of years. Moreover, those who enrol in these subjects in the HG are extremely few (RSA DoE 2001: 8; Horak &

Fricke 2004: 14) despite (RSA DST 2006: 11), numerous public awareness programs that have been undertaken and (Bernstein 2007: 23) great efforts which have been made to enhance the increase of learners in mathematics and science in the education system. A number of researchers have looked at the enrolments and pass rates of learners in general in mathematics and science at grade 12. According to Mangena (2002: 3 of 5), the national statistics reveal that Blacks are not doing well in mathematics and science. Hofmeyr (2006: 6) documents that, in 2002, of the grade 12 learners who wrote mathematics and science, less than 5000 were Blacks and only 700 obtained an A, B or C symbol, which is an indication of readiness for entrance into tertiary levels of education. In 2005, out of half a million learners who sat for the grade 12 examinations, 26 383 learners achieved university entrance. The performance of Blacks was still not good. According to Moleke (2006: 5), because very few Black students pass mathematics and science in school, there is a low throughput rate of Blacks at HE institutions in the SET programs.

Subotzky (2003: 1 of 5) states that the country's population totals about 44 million, of which 70% is Black, 16% is White, 10% is Coloured and 4% is Indian. Although Black students' enrolments have escalated between 1993 and 2000 in South African universities and universities of technology (technikons), their numbers in SET programs remain low (Higher Education in Africa 2008: 9 of 19). Pocock (2004: 10) indicates that in the Chemical Engineering field at the University of Natal, the enrolment of Black students in the first year has remained low since 1990.

Lickindorf (2005: 390-392) argues that after the democratic elections in South Africa, discussions were held by the United Kingdom and South Africa. These discussions aimed at assisting previously disadvantaged universities in developing proficiency and status in SET and improving access of Black staff to South Africa's higher education sector, in view of the fact that White teaching staff, are in the majority in this sector. A primary concern in these discussions was that a mere 30% of graduates at bachelor's, honours and master's levels in the natural and engineering sciences were Black, and those obtaining a doctorate degree were at 10%, despite the fact that 84% of South Africa's population was Non-white. Additionally, in 1991 80 % of South Africa's workforce in SET, were White. Mangena (2005: 3 of 4), citing different statistics, confirms that although Blacks account for 90% of South Africa's population, they only form 2% of South Africa's scientific population.

Despite the great numbers of Blacks in South Africa, many Black students still do not enrol in significant numbers in the SET fields of study. Many of them still enrol extensively in the Humanities at HE institutions. Therefore schools which serve the majority of Black learners should encourage Black learners to enrol in greater numbers in mathematics and science.

2.2.4 Interest and/or performance in the SET sector of different race groups in the rest of the world

Racial disparity in SET programs and careers is also evident in other countries. Loya (2000: 35) notes that the numbers of African American, Hispanic, American Indian and Asian graduate students in SET are still disappointing when compared to the number of Whites in SET. According to Kuh (2001: 47 of 96), in Bachelor's degrees to PhDs, Whites and Asian Americans seem to be more inclined to enrol in SET than are African Americans, Latinos and American Indians. From grades 4, 8 and 12, White and Asian/Pacific Island learners have consistently obtained better marks in mathematics and science at school level than Black, Hispanic and American Indian students (Slashinski 2004: 1) although the gap is shrinking. A report provided by Inside Higher Education (2009: 2 of 5) documents that the number of engineering degrees as opposed to all Bachelors' degrees conferred in America, dropped between 1995 and 2005 for all ethnic groups, with the exception of American Indians and Alaska Natives. This result is different from the previous result with regard to American Indians.

Rosenhall (2007: 4 of 6) indicates that test scores, in the standardised mathematics and English test which is taken annually by learners from grade 2 to 11, show that White and Asian American students performed better than

Latino and African American students in these tests. Although there have been overall improvements in performance over a few years, the Latino and African American learners have not shown any remarkable improvements. Inside Higher Education (2009: 2 of 5) reports that the disparity between Black and White educational achievements has lessened over the years "…but not disappeared".

Gatta and Trigg (2001: 23-24) state that racial and ethnic 'minorities' (a term usually associated with East Asian Americans, Indian Americans, African Americans, Hispanics and Latinos) in the United States are confronted by a lack of entry into high quality education in mathematics and science education and in other subject areas during the K-12 years. As a result, minority groups, including Hispanics, African Americans and American Indians, do not perform as well in secondary school as do their White counterparts. It was noticed that where secondary school minority groups' enrolments are high, there are few advanced mathematics and science courses and programs. Citing research undertaken by Smyth and McArdle (2004), Frehill et al. (2004: 28), indicate that persistence rates of 5 074 college students who have indicated an intention to major in science subjects was examined. Research results revealed that at selective education institutions, students with high persistent rates were those who received prior adequate academic preparation in science at secondary school. Asian students had the highest persistent rates and they were followed by White students. American Indians, Hispanics and African American students showed relatively lower persistence rates.

Garner (2008: 1 of 3), offering contrasting results, reports that in the United Kingdom (UK), White learners seem to avoid mathematics and science and believe that successful people in mathematics are naturally gifted, while Asian and Chinese learners believe that what is needed to be successful, is hard work. In chemistry Pakistan and Indian learners are 7.2 times and 4.3 times, respectively, more likely to progress to chemistry A-level than White learners with same level of achievement. In Bangladesh, Black and Chinese learners are more likely to continue to chemistry A level than Whites are. A similar pattern was also seen in mathematics, with Chinese, Indian, Pakistan, Bangladesh and Black learners more likely to progress to mathematics A-level than their White counterparts.

Given these facts it seems as if some ethnic minorities such as African Americans, Hispanics, American Indians and Latinos in the United States of America (USA) find themselves in more or less the same situation as that of Black students in South Africa. Despite their poor performance in science and mathematics they are also confronted with schools which do not provide advanced courses in SET. This situation already hampers their efforts to be on the same footing with their White counterparts in the SET programs and fields of study. As a result parity between ethnic minority students and White students in educational opportunities, especially in SET, will probably not be reached in the near future.

When analysing the study undertaken by Garner (2008: 1 of 3) it is found that the situation in the UK differs from that of the USA. White learners in the UK seem to have negative attitudes towards mathematics and science despite the equal educational opportunities that different race groups might have in that country. They do not seem to have any problems to access educational opportunities in SET fields of study, as reported above. Garner (2008: 1-3 of 3), however does not provide information on the performance of Black British learners in mathematics and science relative to that of White students.

2.2.5 Interest and/or performance in SET of males and females in South Africa

Concerning science as a school subject in South Africa, data supplied by Edusource Data News (2003: 22-23) indicate that the performance of females in mathematics HG in grade 12 improved significantly between 1996 and 2002. At the same time female enrolments in mathematics and physical science were growing more quickly than male enrolments. However, females were less keen to enrol in mathematics HG and rather opted for mathematics SG.

When one examines data supplied by the RSA DoE (2003-2006) they show that the gender gap between males and females in general is closing in participation and pass rates in mathematics and physical science at school level, although statistical data are unavailable for 2007 and 2008. The following statistics attest to this argument:

Table 1: Senior Certificate examination results for Mathematics and Physical Science HG by gender between 2000 and 2006 in South Africa.

Subject	Year	Number of Candidates who Wrote			Number and Percentages of Candidates who Passed				
		Female	Male	Total	Female	Female %	Male	Male %	Total %
Mathematics Higher Grade	2000	18219	20301	38520	11482	63.0	13395	66	64.6
	2001	16707	18163	34870	11989	71.8	13395	73.7	72.8
	2002	16598	18867	35465	11880	71.6	13635	72.3	71.9
	2003	16618	19338	35956	13096	78.8	15597	80.7	79.8
	2004	18120	21819	39939	13480	74.4	16606	76.1	75.3
	2005	20051	24002	44053	14138	70.5	17974	74.9	72.9
	2006	21321	25624	46945	14547	68.2	18565	72.5	70.5
Physical Science Higher Grade	2000	25582	30117	55699	15718	61.4	20565	68.3	65.1
	2001	22311	26685	48996	15482	69.4	19972	74.8	72.4
	2002	22713	28279	50992	16998	74.8	21912	77.5	76.3
	2003	23105	28975	52080	17177	74.3	22827	74.3	76.8
	2004	24371	31598	55969	17566	72.1	23952	75.8	74.2
	2005	27743	34594	62337	19766	71.2	25886	74.8	73.2
	2006	31266	38036	69302	20687	66.2	27683	72.6	69.7

(RSA DoE Education Statistics in South Africa 2000-2006).

The table shows that from 2000 to 2006 there have been gender differences in achievement at grade 12 in mathematics and science HG, although not extensively. The percentage of passes for males in both physical science and mathematics HG is somewhat higher than that of females. The male enrolment has throughout been higher than that of females. It must however be noted that these results are for all racial groups representing all types of schools.

According to the Minister of Education, Naledi Pandor (2008: 4 of 5), in 2008 there were positive achievements in mathematics and science in grade 12 although it is not yet clear how females compared with males with regard to pass rates. The Parliamentary Monitoring Group (2009: 1 of 7) further claims that the subjects in which grade 12 learners scored the lowest in 2008 were accounting, agricultural science, mathematics and physical science. Females generally performed better in most subjects except in agricultural science, geography, history, mathematics and physical science. No Improvement in Matric Maths (2009: 2 of 3) indicates that, despite the positive achievements in mathematics and science of grade 12 learners in 2008 as reported by Naledi Pandor above, about 60% of students had still not performed well in mathematics. By contrast, there was an extremely high pass rate in mathematical literacy of about 78.7%. Because of this high pass rate in mathematical literacy, No improvements in matric maths (2009: 2 of 3) feels that many learners will choose to study mathematical literacy as a simpler alternative to mathematics, as a result "…this appeared to defeat the intended outcome of producing more potential in South African students to follow careers in mathematics-based disciplines".

The data base of the Free State Education Department (FSDoE) in 2006, showed that in mathematics HG the pass rate was 70%. Males with A symbols accounted for 5.3%, while female learners accounted for 4.5%. In mathematics SG the pass rate was 51.2%. Males accounted for 2.3% of A symbols, while females accounted for 1.4% of A symbols. For physical science SG the pass rate was 50.7%. Males with A symbols accounted for 2.3%, while females with A symbols accounted for 1.8%. For physical science

SG the pass rate was 57.7%. Males with A symbols accounted for 0.1%, while female with A symbols accounted for 0.05% of the total group. These statistics clearly depict that males are still performing better than females in these subjects (RSA FSDoE 2006).

Concerning HE institutions, at the Vaal University of Technology 21% of students who enrolled for the engineering undergraduate degree in 2000 (Sutherland & Joubert 2004: 19) were females. Research indicates that South Africa experienced a remarkable improvement in the participation of women in the SET workforce between 1992 and 2001 (RSA DST 2004: 21), although some inequities still continue. Liebenberg (2002: 3) notes that South Africa produces about 1800 engineering graduates every year, of which only 8% are women, and only 238 women, register as professional engineers compared to 15 534 males. The Department of Science and Technology, RSA DST (2004: 12) maintains that women are still under-represented in the natural sciences and engineering; specifically engineering.

Statistics (RSA DST 2004: 27) reveal that in 2001, 61% (3370 out of 5514) of women instruction staff were concentrated in the social sciences and humanities as compared to 50% (3970 out of 7938) of men. In the natural sciences and engineering, 38% (3020) were men and 21% (1154) were women. When looking at natural science and engineering female instruction, women were mostly represented in the computer sciences and badly represented in engineering. In 2001 nine percent (75 out of 831) of women were instruction staff and 14% (33 out of 230) were research staff, and the senior academic ranks were dominated by men, where 26% were professors as opposed to only 7% who were women. In terms of publication outputs, the Centre for Research on Science and Technology (CREST 2005: 9) reports that women produce very few SET publications as opposed to men. It is also documented that in the 1990s women were responsible for only one fifth of publications in SET fields of study.

An Information and Communication Technology (ICT) audit conducted in 2005 revealed that although 55% of women ICT workers held Higher Education and

Training (HET) qualifications, the minority of women, in contrast to men, were employed as ICT managers, engineers, programmers, technicians and artisans. A majority of women, however, is concentrated in technical sales and system analyst professions (James 2006: 47 of 75).

On the whole, the SET fields of study and careers seem to be still dominated by men in South Africa. Gender disparities are still noticeable because more men than women are found to occupy higher positions in the SET sector.

2.2.6 Interest and/or performance in SET of males and females in the rest of the world

Literature reveals that the issue of under-representation of women in general in science, engineering and technology (SET) is a worldwide problem (Sutherland & Joubert 2004: 19; Engle 2003: 5). In African higher education institutions, gender disparities are still observed between Black males and females, especially in the sciences. In Kenya (Teferra & Altbach 2004: 36) only 10% of females are enrolled in engineering and technology programs in public universities and in the natural sciences very low numbers of females are documented to be within public HE, and in Mauritius males are seen to dominate the Engineering Faculty. In Nigeria, Osiruemu (2007: 104) further contends that a large number of women are still found in teaching, catering, law and nursing, while in professions such as engineering and architecture the percentage of women is low in comparison to that of men. Assie-Lumumba (2006: 19) declares that higher education persists to be clearly dominated by males, more especially in science, technology and management. Assie-Lumumba (2006: 19) further indicates that in Nigeria women academic staff in the sciences accounted for 12.8% between 1996 and 1997. Those who enrolled for the sciences were at about 31.7%. Citing research done by Effah (2003), Assie-Lumumba (2006: 19) states that in Ghana, female enrolments increased from 21% to only 26% between 1991 and 1992.

The Science and Technology policy for Malawi confirms that 52% of the population in Malawi consists of women but not many are inspired to pursue science and technology studies (Gomile-Chidyaonga 2003: 2). Statistics between 1999 and 2003 indicate that there were some improvements in the enrolments of women in SET related disciplines. From 1999 to 2002 the enrolment of women in civil engineering increased from 7% to 9%; electrical engineering increased from 13% to 15% and in mechanical engineering no female enrolments were documented. For a degree in Architecture female enrolments dropped from 33% in 2000 to 31% in 2003. Female enrolments in the Environmental Health program increased from 9% to 27%, while 50% of women enrolled for Information Technology, Business Information Systems and Laboratory Technology Diplomas. An increase from 8% to 39% was documented for the Bachelor of Technical Education degree between 1999 and 2003 (Gomile-Chidyaonga 2003: 2).

Kennedy and Parks (2000: 533); Gray (2005: 6 of 16); Brownlow, Jacobi and Rogers (2000: 120), confirm that the performance of males and females in mathematics and science is not significantly different, but by the end of the secondary school gender differences are evident in American schools. In this regard Halpern, Aronson, Reimer, Simpkins, Star and Wentzel (2007: 6) mention that girls seem to doubt their capability in mathematics and science. Sullivan (2006) argues that, although young women dominate as US secondary school graduates, they are still less visible in the engineering pipeline. Females account for only 20% of new B.S. Engineering enrolments. Interestingly enough, citing research done by Brandon (1991), Yu and Sandra (2008: 7 of 20) document that "…Asian American women had as high a percentage of women in engineering majors (9%) as male students of any other group". Yu and Sandra (2008: 6 of 20) further mention that both Asian American women and men are highly represented in SET as researched by Suzuki (1998) and the NSF (2004). Referring to studies conducted by the NSF (2004), Yu and Sandra (2008: 2 of 20) confirm that the rate at which Asian Americans earn science and engineering bachelors' degrees is increasing when compared to the rate of White students. Hence Asian Americans are labelled as the 'model minority' (Yu & Sandra 2008: 2 of 20).

In the more industrialised countries, CREST (2005: 14) suggests that there have been dramatic improvements in female enrolments for higher education degrees in South Africa, but women are still under-represented in SET. Moletsane and Reddy (2008: 8-9) note that, in the United Kingdom, out of 44% of Masters degrees and 37% of PhDs awarded in SET, women only make up a quarter of the workforce. In most European countries women are less represented in engineering with 6.4% women in Denmark, 2% in Ireland and 5% in France.

Statistics provided by Women in Science and Engineering (WISE) (in Sutherland & Joubert 2004: 19) reveal that only 20% of women in Canada and 17% of women in America have enrolled in undergraduate engineering fields of study over the past few years. In the USA women make up 8.5% of engineers, in Japan 2.9% and in France 22% (Liebenberg 2002: 3). In Sweden the number of females in the engineering bachelor's program is at 26%, which, according to Gustafsson (2000: 21), is a fairly high percentage against an international setting.

In Britain studies conducted by Ochugboju (2000: 12) document that women comprise less than 15% of the science and engineering professional and technical labour force. In information technology and engineering, representation is extremely low, while in skilled engineering trades 2.5% of the workforce is made up of women. Ochugboju (2000: 12) further indicates that in all SET sectors women are found to be less represented, especially at senior levels and the rate at which women progress in their careers is slower than that of males.

CREST (2005: 14) further documents that in the United Kingdom very few women enrol for physical science, mathematics and computer sciences at undergraduate level and the situation becomes even worse at post graduate level. In Europe, although numbers of females obtaining degrees in SET fields are increasing, they are still grossly under-represented in higher scientific positions, and furthermore, very few women occupy senior positions in the SET workforce.

In teacher training programmes in California, a study conducted by Swan (1999: 4 of 34) found that most of the female candidates were enrolled to study teaching in primary schools. In secondary schools male and female teacher enrolments were more or less equal with a higher percentage of males enrolling to teach mathematics, science and technology.

Coulter (1999: 118) confirms that, in Canada, despite a number of programmes funded by government and the private sector to increase girls' enrolments in science and mathematics, women have persisted in their reluctance to study these subjects in secondary schools when these subjects become optional. In addition, women fail to increase enrolments in engineering and applied sciences at tertiary institutions. Interestingly, a survey conducted by the Foundation for Research Development in partnership with the Human Sciences Research Council (HSRC) in 1995, showed that out of 20 nations, Canada was the best performing country in scientific and technological literacy [(Department of Arts, Culture, Science and Technology) (RSA DACST 1998: 5)]. It is, however, surprising to find that women in Canada avoid studying in the SET fields.

Lessons in Learning (2007: 2-3 of 9) reveals that in 2001 15% of women in Canada had a university degree and outnumbered men in most post-secondary fields of study. But women still persist in being under-represented in SET fields of study. In 2006 women comprised 47% of the workforce in Canada, but the percentage of women in professional, scientific and technical services had dropped in relation to the proportion of women in the labour force.

The under-representation of women in science is addressed in many countries, such as the United Kingdom, Canada and the United States (CREST 2005:12). These countries have compiled information on the status of women in SET in order to address this problem. Citing McGregor & Bazi

(2001), CREST (2005: 13), documents that there are a number of initiatives for women in SET internationally which aim at improving the representation of women in SET fields of study and careers.

This literature review suggests that women in general are under-represented in SET globally. Males and females appear to perform equally well in mathematics and science at school but females lose interest in these subjects by the end of their secondary school years. On the contrary, Asian American women are found to be highly represented in the SET and consistently pursue SET fields of study and careers. Educational institutions and planners are confronted with challenges of diagnosing these problems and coming up with solutions to change this situation in order to attract, increase and sustain female enrolments in the SET fields of study.

2.2.7 Interest and/or performance in SET of Black females and Black males in South Africa

When one examines the interest or performance in SET of Black females in South Africa the picture for such women in particular becomes more gloomy. The Edusource Data News (2003: 24) documents that the 2002 grade 12 results in South Africa for physical science and mathematics HG revealed that the performance of Black females was poorer than that of their Black male counterparts. The percentage of passes for physical science HG was 26.6 % for males and 19.9 % for female, and for mathematics HG it was 31.1% for Black males and 22.8% for Black females.

In a study conducted by Maree et al. (2006: 231-237) in May 2002, in Mpumalanga secondary schools with grade 8 and 9 learners, learners had to complete tests which required a basic understanding of science and mathematics processes relevant to the grade 8 and 9 level. The overall results revealed that students in general did not perform well in the science and mathematics tests. Regarding contrasting results for Black males' and Black females' achievements in the science and mathematics tests, as documented by the Edusource Data News(2003: 24) above, Maree et al.

(2006: 231- 237), report that there were no major differences between the achievements of Black male and Black female grade 8 and 9 learners in the science and mathematics results.

These contrasting results reported by Maree et al (2006: 231-237) confirm studies undertaken by Kennedy and Parks (2000: 533); Gray (2005: 6 of 16) and Brownlow et al. (2000: 120), which indicate that the performance of males and females in mathematics and science is not significantly different in early secondary school years but becomes significantly different by the end of secondary school.

To analyse the performance of Black learners in science and mathematics in South Africa, Kahn (2004: 150) used the language proxy method to track Black learners' achievement in these subjects between 1999 and 2002, with the assumption that the studying of a Black language could be a good indication for being Black. Kahn (2004: 149) indicates that this was the only method he could use to determine the performance of Black learners in mathematics and science because there were no reliable data before the move to democracy. Furthermore, it was policy not to gather racially disaggregated data between 1994 and 2001. Kahn (2004: 150) confirms that although this method was not 100% accurate it gave an indication of the status of Black learners in mathematics and science because the education system of the past forbade efforts to examine the performance of Blacks in these subjects. The Language Proxy method revealed the following results, (Kahn 2004: 151-154):

Table 2: Language Proxy group with male: female pass rate by province for 2002

Province	Mathematics Higher Grade		Mathematics Standard Grade		Physical Science Higher Grade		Physical Science Standard Grade	
	Male %	Female %	Male %	Female %	Male %	Female %	Male %	Female %
Western Cape	69.4	54.1	46.7	33.3	65.3	54.7	61.2	50.3
Northern Cape	61.1	30.0	75.2	55.1	73.7	66.7	79.0	71.2
Free State	54.1	41.3	52.2	37.0	33.2	18.5	57.0	46.3
Eastern Cape	41.9	33.8	41.3	29.7	42.0	28.4	48.0	39.6
KwaZulu Natal	21.6	12.4	37.1	27.1	25.1	20.0	57.1	52.1
Mpumalanga	29.8	11.4	34.5	20.6	21.2	10.4	41.0	32.3
Limpopo	23.2	10.8	41.0	28.4	22.6	13.6	53.7	47.1
Gauteng	32.9	29.8	43.4	29.6	29.1	25.4	55.1	47.2
North West	46.4	35.5	38.6	28.6	32.7	22.5	50.0	43.2

Source: Internal data of the Department of Education (Kahn 2004: 151-154).

When the language proxy method was used to compare Black male and Black female pass rates by province in 2002, it was found that Black males performed better than Black females in all subjects across provinces. When the performance of Black males and females who do not take a home language as an examination subject was compared, it was found that there were no consistent gender differences between males' and females' performance in mathematics and science. Black females performed better in five of the nine provinces. However, there was a difference between the performance of Black males and females who take their home language as an examination subject. Kahn (2004: 154) believes that the explanation for the dissimilar performance between Black males and females who do not take their home language as an examination subject and Black males and females who take their home language as an examination subject, was that the non-mother tongue group was exposed to a different type of school, either an independent or a former Model C school. When one examines the pass rates, as portrayed by the proxy method, the picture is not good for Black females.

The Facing the Facts study (RSA DST 2004: 13) indicates that, although Blacks in general are under-represented in SET fields of study and careers, Black men are still found to be more represented at the SET doctoral enrolments and graduations than Black females. In 2001 Doctoral enrolments and graduations for Black males and females were at 31% and 21%; and 25% and 15%, respectively.

In summary, not much research has been done on the performance and pass rates of Black females in particular in SET programs and fields of study in South Africa, but the available research indicates that Black females, particularly those who attend school at historically Black schools, do not perform as well as their Black female counterparts who attend former Model C schools. In 'Black' schools, Black males appear to perform better in mathematics and science than Black females do. If the type of school has an influence in the performance of learners in mathematics and science then the majority of Black females in South Africa will most probably not be able to feature in the SET fields of study and careers, because most of them still attend 'Black' schools.

2.2.8 Interest and/or performance in SET of Black females and females of other races in South Africa

When a comparison is drawn between the position of Black women and women of other races in South Africa, literature reveals that, although the data supplied by the RSA DoE (2003-2006) reported a decrease in the gender gap participation and pass rates in mathematics and physical science at school level between males and females in general, the situation has not changed for Black females. The Edusource Data News (2003: 23) showed that in the 2002 matric results in South Africa, White and Indian females performed better in physical science HG, with pass rates of 87.7% and 75.4% respectively, while Black females' pass rate was only 19.9%. In mathematics HG in the same year, White and Indian females' pass rates were 88.9% and 72.3% respectively, while Black females' pass rate was 22.8%.

When one examines doctoral enrolments and graduations by race in 2001, White women accounted for 65% of all female doctoral enrolments and 76% of all female doctoral graduates. Black females accounted for a mere 21% of doctoral enrolments and 15% of doctoral graduates (RSA DST 2004: 28). Furthermore, in the same year it was found that White females represent about 70% of academic staff in higher education. Black, Coloured and Asian females account for 33% of the Reconstruction and Development (R&D) personnel.

While there is increasing opportunity and access to formal education, Brown (2006: 1 of 6) specifies that Black women are still "…under-represented, under-employed and under-valued". Black women seem to have lower levels of education than all other groups. This research indicates that, in 2004, grade 12 results showed that low numbers of Black candidates passed mathematics and physical science at HG and numbers were even worse for Black females. Citing research done by the Community Agency for Social Inquiry (CASE), Brown (2006: 2 of 2) confirms that Black women graduates increase by about 8% per year but they are still insufficiently represented in SET. The study conducted by Women in Science (2003-2007: 1) showed that, at doctoral levels, Black women are under-represented in the natural sciences and engineering, as well as in the social sciences and humanities.

When commenting on the present situation of Blacks in general in South Africa, at a symposium organised by the South African Agency for Science and Technology Advancement (SAASTA) (2008), Professor Cheryl De La Rey said, "… We were very disappointed to find that Black women in particular were not represented in many SET careers, such as in electrical engineering. This is a concern and it is something that we should look at with partners in higher learning institutions and the private sector". James (2006: 65 of 75), however, argues that there is not much research muscle in the country on SET and ICT research and as such it becomes difficult to build up sensible strategies to increase the number of women in the SET and the ICT sector.

In conclusion, it appears that Black women do not perform as well in the SET fields of study as do women of other races in South Africa from as early as the secondary schools years. This might be the reason why the position of Black women in the SET fields of study in HE institutions and careers in South Africa is discouraging.

2.2.9 Interest and/or performance in SET of females of different race groups in the rest of the world

While research suggests that women of all races are under-represented in the SET fields and careers, the situation of African American females in the USA is also discouraging (Loya 2000: 29). Although a literature study that has been undertaken, strongly argues that women in general are under-represented in SET fields of study and work places, statistical data are lacking as far as Black women in particular are concerned, internationally. Bebbington (2002: 362) argues that in most European countries ethnicity data are absent and this makes it difficult to monitor the involvement of ethnic minority women in SET. Furthermore, Bebbington (2002: 371) complains of a tendency to regard women as a solitary, integrated group when statistical analyses are carried out in scientific employment whereby data disaggregated by ethnicity are not often presented. The reason given is that the numbers are too small. As such the problem of the under-representation of women in general in SET "… cannot be quantified and tackled". Gatta and Trigg (2001: 24-26) confirm that minority groups, particularly African Americans, do not perform well in mathematics and science at secondary school level and are still lagging behind in obtaining bachelor's degrees in SET.

Despite increasing enrolments of women in tertiary institutions, women have seemingly continued to be under-represented in SET fields in secondary schools, higher education institutions and the workplace, internationally. This matter has been under discussion especially in Australia (Goodell1998: 1 of 6), the United Kingdom (Bebbington 2002: 360), the United States (Kuh 2001: 44 of 96), Canada (Coulter 1999: 118) and Africa (Teferra & Altbach 2004: 36). In addition, the matter has been receiving attention internationally in organisations such as the United Nations and the European Commission (RSA DST: 2004: 22).

Bebbington (2002: 361) highlights the fact that in the USA African-Carribean women are under-represented as science students from school through higher education hence their under-representation in scientific employment, despite their numbers in the general population. Gatta and Trigg (2001: 25) comment that in the USA the majority of White and Asian females enrol in Advanced Placement Science and Mathematics courses. These courses provide students with opportunities to gain college credits for secondary school work and aid them in enrolling at the best colleges. By contrast it was found that Latinos and African American females have about half the enrolments when compared to White and Asian females. Loya (2000: 30) accentuates that in 1997 African American, Hispanic and American Indian women were markedly under-represented in SET at colleges when compared to White women, while Asian women were well represented. Research done by Yu and Sandra (2008: 6 of 20) confirm that Asian American women perform better in SET than White American women. In the New York region's Westinghouse Science Talent Search, which took place between 1975 and 1983, among Asian Americans who won the Talent Search half were women and only a quarter of the winners were White American women.

There are indications that African American females are under-represented in respect of science and engineering degrees at all levels. Loya (2000: 36) states that for both males and females, African American recipients of Masters' degrees in SET in 1998 were at about 2.5%. The National academy of Sciences (2006: 3) also found that women from minority racial and ethnic groups are grossly under-represented if not absent from SET senior ranks. In Pakistan, Bangaldesh and Black Carribean Countries, females who want to pursue their studies, especially in SET fields, are hampered by inadequate preparation that would have assisted them in making informed choices (Osiruemu 2007: 103-104).

Fancsali (n.d) indicates that in 1997 5% of all scientists and engineers in the labour force were women, Blacks accounted for 1%, Hispanic women for 1%, American Indian women for 0.1% , and Asian women accounted for 2%.

In conclusion, it can be said that ethnic females appear to be grossly under-represented in SET fields of study and careers. Ethnic females seem to receive a poorer education in SET than their White counterparts do at school level. This prohibits them from pursuing scientific fields of study at HE institutions. As a result they will most probably continue to be less represented in the SET fields of study. As a result of this measures are certainly needed to counteract female under-representation in SET, with a special focus on Black females.

2.3 Policies and guidelines to increase enrolments in SET in South Africa

In responding to problems of under-representation of women in SET, and in attempting to increase and diversify women's participation in SET, there are policies and guidelines the South African government has put in place. CREST (2005: 9-10) documents amongst others, two policy areas mainly related to studies of women in science and technology, and higher education. These policy documents and strategies incorporate the White Paper on Science and Technology and its related National Reconstruction and Development (R&D) Strategy; and the White Paper on Higher Education and its interrelated National Plan for Higher Education. The R&D strategy is aimed at identifying ways of increasing the human resource foundation in connection with women and Blacks. The National Plan, on the other hand, focuses on human resource issues from the supply side.

CREST (2005: 9) documents that the R&D strategy found that Black and female scientists, engineers and technologists do not enter "…the academic publishing ranks and that the key research infrastructure is composed of people who will soon retire". The White Paper on higher education brought to light a series of flaws and major challenges in the higher education system. One of the challenges was found to be an unfair distribution of right of entry and possibilities for students and staff along racial lines, gender, class and geographical setting, and a lack of substantially qualified graduates in SET and commerce, due to the limited access of Black and female students, because of biased education systems of the past. The National Plan indicated that, although gender equity has been attained in universities, it is still a drawback in universities of technology (technikons). Moreover, female students in general are still concentrated in humanities and are poorly represented in SET and in post graduate programs, in academic and professional ranks, and especially at senior levels. The situation is worse for Black people in particular.

To remedy the situation the new integrated science curriculum was developed. In the General Education and Training Band (GET) natural sciences, technology and mathematics are compulsory while in the Further Education and Training Band (FET) mathematical literacy and mathematics are compulsory (RSA DST 2006: 10) (as indicated in 2.1 above). The Strategy to increase enrolments in SET was to use Olympiads, Competitions and Camps to discover and support learners, especially Black and girl learners with ability and potential. The aim is to increase the number of learners doing well in mathematics and science HG, with special emphasis on schools from disadvantaged backgrounds (RSA DST 2006: 13). The following Olympiads and Competitions were established:

- Eskom Expo for Young Scientists

- UCT Maths Competition
- Minteq Minquiz
- Pan African Mathematics Olympiad
- South African Mathematics Olympiad
- Interprovincial Mathematics Olympiad
- ISPAT ISCOR National Science Olympiad
- National Natural Science and Biology Olympiads

A SWOT analysis of the data collected from 5 of the 8 Olympiads and Competitions, by the DST, revealed that the participation of girls is low and those that do take part do not do so as keenly as boys do. It has also been noted that the number of Blacks participating in these Olympiads and Competitions is still low and their performance is still poor (RSA DST 2006: 13).

The main initiative of the Department of Education (DoE) is the Dinaledi Project. The project was initially aimed at improving the performance of Black learners and former Black schools rather than White, Coloured and Asian schools in mathematics and science HG, although at a later stage some former White schools in Gauteng, the Western Cape and KwaZulu Natal were included (Bernstein 2007: 11). Bernstein (2007: 11) confirms that the effect of the Dinaledi project is difficult to determine and the analysis of the project shows that most of the HG mathematics and science passes are obtained by a few high performing schools and that in most schools performance has not changed, while in some schools it has actually declined. Furthermore, it was found that the initiatives to increase participation in mathematics and science at national, regional and local levels sponsored by private companies have little lasting impact on the quality of mathematics and science in schools. Bernstein (2007: 12) indicates that these private companies have to relocate their efforts on changes in the system that can have desirable effects on the quality of mathematics and science in the schooling system, and that the Dinaledi project has also not yet achieved its goals.

The DST negotiated a bilateral research programme with foreign partners and the National Research Foundation (NRF) in 1996. This programme of scientific interactions between the United Kingdom (UK) and South Africa aimed at supporting historically deprived universities in order to develop skills and excellence in certain areas of science, engineering and technology (Lickindorf 2005: 392). Its objectives were to:

- *"Increase the number and quality of Black researchers and lecturers in science, engineering and technology in South African universities;*
- *Improve access of Black staff in the South African higher education sector to UK research and research institutions;*
- *Establish centres of excellence in historically disadvantaged universities through the assistance of UK experts;* and
- *Encourage collaborative research projects between centres of excellence in Britain and South Africa"* (Lickindorf 2005: 392).

Lickindorf (2005: 392) mentions that the bilateral projects still benefit White male researchers from historically White universities and that "race groups" with relatively low numbers of researchers are not even aware of opportunities provided by these bilateral programs.

Although there are increasing opportunities and access "…choice of field of study and lower levels of progression into postgraduate level place Black women at a disadvantage when seeking employment. Enrolment into certain fields, remains predominantly White and male, especially engineering, sciences and technology" (Brown 2006: 2 of 6).

Researchers attribute this under-representation of women and Black women in particular, in SET, to a number of factors such as aptitude for a specific vocation, interest in SET, socio-economic factors, socialisation practices, occupational sex-role stereotypes, lack of self confidence, lack of female role models, lack of vocational guidance in secondary schools, under qualified mathematics and science educators, parental support for a certain career, practical barriers and attitudes towards different vocations .

2.4 Conclusion

In this chapter, it has been attempted to determine whether the representation and performance of Black women in SET in South Africa are similar to or different from that of Black women in other countries; how the representation and performance of Black women in SET in South Africa compare with the position of Black men in the country; and finally, how the position of Black women in SET compare with the position of White women in South Africa and worldwide.

In response to these questions it can be concluded that the position of Black women in South Africa is very similar to the position of Black women in other countries because Black women globally seem to be insufficiently represented in SET fields of study and careers. Furthermore, in South Africa although Black men are seemingly still under-represented in SET, Black women are still the worst represented in these fields. Lastly when the position of Black women is compared to that of White women in South Africa, it is found that White women are better represented in SET than Black women are.

There are therefore indications that Black women in general, on a worldwide scale and in South Africa, are grossly under-represented and perform poorly in SET. Even though Black women are increasing their enrolments at HE institutions in South Africa, the proportion of Black women obtaining degrees in SET is far less than that of White women and Black men. Those exceptionally few who manage to obtain degrees in SET do not occupy senior positions as their male counterparts do, and are unlikely to reach the highest scientific hierarchy.

Given the population statistics of Blacks in general in South Africa, it is evident that the scarcity of skills in the SET sector will most probably not be addressed adequately if Black women in particular are less engaged in these fields.

In searching for the answers as to why Black women do not sufficiently engage in SET fields of study we need to investigate all likely factors that might influence the career choices of young Black women. These factors will be discussed in the next chapter.

CHAPTER 3

FACTORS THAT MIGHT INFLUENCE VOCATIONAL CHOICE OF BLACK WOMEN

3.1 Introduction

A number of studies have attempted to explore and explain the factors that might influence the entry and development of women in science. Research studies in developing countries globally identify a variety of factors that might inhibit women in general in choosing a career in science. Bloye (2007: 10 of 111) classifies these factors into two categories, namely cognitive and non-cognitive factors. Bloye (2007: 10 of 111) confirms that while much international research has been undertaken on these factors which might affect career choices of students, there seems to be few empirical studies within the South African context. De La Rey (2007: 2 of 5) attests that these factors "… make it more challenging for women to succeed in scientific careers".

In South Africa the prevailing attitude towards women and Blacks in science has changed dramatically since the new democratic government has been elected. The changed attitude has resulted in the government initiating policies and guidelines which aim at increasing and diversifying Blacks and women's participation in SET (as discussed in chapter 2). Therefore the focus of this study is to investigate the attitudes and sex-role stereotypes regarding careers in SET, of Black women and to determine whether Black women's attitudes and occupational sex-role stereotypes towards these fields have changed in response to the policies and guidelines regarding SET, which is to increase enrolments into the field at school and university levels.

This chapter focuses on both cognitive and non-cognitive factors regarding decisions for the choice of a career. Aptitude for a specific vocation is a cognitive factor, while non-cognitive factors include interest in a particular subject, parental support, lack of self confidence, practical barriers, distance from the university and attitudes towards different vocations.

3.2 Aptitude for a specific vocation

Citing Corno et al. 2002, Lohman (2005: 337) contends that aptitude is "…the degree of readiness to learn and to perform well in a particular situation or domain". In addition, Lohman (2005: 336) refers to aptitude as something that is not fixed at birth and that individual achievements help form aptitudes. As such, aptitude entails more than cognitive structures such as ability or accomplishments. He further argues that aptitude does not refer to personal attributes independent of the environment but is linked to context.

Research done by a number of researchers such as Rebhorn and Miles (1999: 316); Joyce (1999: 261); Kennedy and Parks (2000: 533) citing studies conducted by Leslie, McClure and Oaxa in their 1998 article; Halpern, Aronson, Reimer, Simpkins, Star and Wentzel (2007: 27) and Fancsali (n.d.:1), confirm that in the USA boys and girls perform equally well in primary school mathematics and science, display confidence and interest in similar ways. These researchers also confirm that interest and confidence in mathematics and science gradually diminishes by the end of secondary school. When students are exposed to the Scholastic Assessment Test (SAT) used when selecting students for admission to colleges and universities, on the mathematics part of the SAT (SAT-M), males are found to perform better than females.

In addition, Spelke (in Musings 2008: 3 of 10) reiterates that men and women are equal in mathematics and science aptitude, and that the resulting equal performance proves that mathematical and scientific reasoning has a biological base found in both males and females. Rebhorn and Miles (1999: 317) argue that if gender differences in mathematics achievement develop during secondary school years, then the environment might be one of the factors contributing to girls' under-representation in science related fields. Citing studies conducted by Paulos (1995), Rebhorn & Miles (1999: 316) believe that the SAT does not measure all dimensions of scholastic ability. These researchers found that when there are no time limits to the completion of the test, gender differences are minimised. It was also found that there are questions in which males constantly do better than girls. It is, however, not clear how these test items affect girls' scores. Rebhorn and Miles (1999: 316) state that these test items are disadvantaging girls' scores in the SAT-M.

Stephen, Welman and Jordaan (2004: 42) state that the use of matriculation symbols seems to be a contentious subject, with numerous researchers providing different results. Regarding this matter Pocock (2004: 13) indicates that "… what matriculation scores tell us is open to debate". Citing research done by Welman (2000), Stephen et al. (2004: 43) indicate that given the historical educational background of Black students in South Africa, matriculation results are not consistent predictors of aptitude for Black students and it is recommended that for them matriculation results cannot be regarded as a true reflection of academic ability. Sadler and Erasmus (2005: 33) also believe that matriculation results cannot predict factors which influence academic success at higher education institutions.

Students' success or failure at higher education institutions has been a bone of contention among many academics (Sadler & Erasmus 2005: 32). These researchers question the effectiveness of selection methods such as matriculation results and SATs which are normally used as selection criteria for entry to universities. They believe that these selection criteria lack empirical support. Sadler and Erasmus (2005: 33), citing studies conducted by Schmelzer, Schmelzer, Figler and Brozo (1987) and Killen (1994), state that the most important factors affecting academic success at higher education institutions could, amongst others, be students' interest in the course and motivation. Sadler and Erasmus (2005: 33) feel that factors such as interest in the course, motivation, self-discipline and effort …"cannot be predicted from matriculation results". Citing studies conducted by Reynolds and Walberg in 1992 and Singh et al. (2002), Tuan, Chin and Shieh (2005: 648) state that students' attitudes and motivation are significant factors in predicting students' success in science while students' motivation is the most crucial aspect in predicting students' attitudes towards science.

In summary, research has shown that aptitude does not play a determining role in the choice of a career but that there are other factors that are not identified yet, that might inhibit women from enrolling in great numbers in SET. While boys and girls perform equally well in science and mathematics at the primary school level and early secondary school years, girls seem to lose interest along the way, especially during their secondary school years.

3.3 Interest in Science, Engineering and Technology

Countryman, Kekelis and Wei (2006: 3) indicate that girls usually seem to lack interest in the SET fields despite the fact that they want to make the world a better place. They do not see how their interests fit in with science, engineering and technology. They prefer to major in social/biological or agricultural science (Slashinski 2004: 2). The same sentiments are shared by Sharf (1997) (in Foster 2005: 9) where it is indicated that interest inventories show that women in general are more interested in arts, clerical and social occupations than men, and display lack of interest in scientific and technological occupations.

Plug, Louw and Meyer, (in Maree & Beck 2004: 80), state that career counselling is a combination of all counselling processes associated with the choice and preparations for a career in the form of interviews, interest questionnaires, aptitude tests and personality tests. Maree and Molepo (2007) found that assistance in career counselling was lacking in many South African schools and as such many learners in Black schools did not receive adequate career counselling. Career guidance opportunities were offered at White schools (Du Toit 2005: 6). Geldenhuys and De Lange (2007: 129) cite Botha and Ackerman (1997) when indicating that lack of guidance in choosing school subjects has been a barrier in the sense that Black adolescents in South Africa are seemingly not capable of making informed career decisions. In addition, career counselling in South Africa is still expensive and can only be accessed by people who can afford it, while poor communities are further disadvantaged (Maree & Beck 2004: 8; Maree & Molepo 2007).

It has been documented that the traditional methods of career counselling do not provide adequate results in respect of different populations in the South African context because they have been widely applied in regard to White South Africans only. Because these traditional methods of counselling are still based on Western principles they are not necessarily legitimate and trustworthy for use among the diverse South African cultures (Maree & Molepo 2007; Maree & Beck 2004: 81).

Ebersöhn and Mbetse (2003: 324) state that the present structure of career education is complicated. In South African schools career education is addressed in the Life Orientation learning area. These researchers assert that educators in the Limpopo rural community expressed their lack of skills in offering career education to learners (Maree & Molepo: 2007) and in engaging with career counselling matters. Another disturbing issue (Ebersöhn & Mbetse 2003: 324) is the tendency of schools to allocate Life Orientation to any educator in order to fill gaps in the timetable and this further derails career education.

Vocational interest inventories have been found to be gender biased (Foster 2005: 43; O'Malley & Richardson 1985: 295). Foster (2005: 43) substantiates that aptitude tests are different in norm scores. Scores given to spatial visualization for males and females were found to be different. Citing studies by Sharf 1997, Foster (2005: 43) verifies that although improvements have been made to these inventories, they still only reaffirm societal stereotypes.

O'Malley and Richardson (1985: 298) conducted studies with 249 counsellors in the USA and in Canada. Their results also showed that counsellors hold stereotypical beliefs about men and women. These researchers believe that career counselling can yield negative results to clients if counsellors are found to favour societal role stereotypes and that the selection of therapeutic ideas and procedures can be affected by the counsellors' expectations and perceptions of what clients desire.

Chae (2002: 147) cites earlier research conducted by Broverman, Broverman, Clarkson, Rosenkrantz and Vogel in 1979, who found that counsellors set double standards for women. More socially popular qualities were credited to "healthy men" than to "healthy women". Furthermore Chae (2002: 147), referring to studies conducted by Herr and Craimer (1992) and Worrell (1980), found that counsellors displayed negative attitudes towards women pursuing non-traditional careers requiring mathematics or science experience. Citing studies conducted by Donahue and Costar (1977), Chae (2002: 147) documents that secondary school counsellors had a tendency of recommending lower paid jobs which are highly supervised and required minimal education for girls. These recommendations were not applicable to boys.

In short, research results on interest inventories indicate that interest inventories can yield positive and/or negative effects regarding career choices of girls depending on the person administering these tests. Due to lack of career guidance in Black schools in South Africa, Black students seem not to be exposed to different careers from which they may choose, as their White student counterparts are. Even though career counselling services are now available they are still expensive and this further prohibits Black students in general from accessing such services.

3.4 Parental support for a certain career

In this section two aspects related to parental support for a certain career are discussed, firstly parents as role models and secondly, parental support and encouragement.

3.4.1 Parents as role models

The level of education of the parents plays an important role in the career aspirations of adolescents, according to Mortimer, Dennehy and Lee (1982) (in Besecke & Reilly 2006: 4 of 17). Citing research conducted by Lemkau (1983), Besecke and Reilly (2005: 4 of 17) indicate that women in non-traditional occupations have more regularly encountered family environments which are enhanced by different models in which they were motivated to explore an unusually wide range of behaviours and career options. These women were more likely to state the positive influence of men or fathers and male teachers, while women following traditional careers would recount more female influences.

In addition, Kracke (1997), (in Foster 2005: 43), confirms that parents who promote children's independent thinking and exploration of careers tend to develop children who are more capable of exploring careers than the children of parents who do not encourage independent thinking. The same findings have been reported in an American survey of women engineers and those still studying at university. The majority of women engineers or those studying engineering reported having a close family member who is an engineer (Liebenberg 2002: 4; Monhardt et al. 1999: 536).

Bandura, Barbaranelli, Caprara, and Pastorelli (2001: 189) contend that much research has been conducted on the influence parents have on their children's academic achievements, but that little research has been done on how parental influence affects career developments of children. Bandura et al. (2001: 189) believe that parents with high academic efficacy instil the desire for scholastic success and accomplishment in their children. Bandura et al. (2001: 189) claim that such parents would generally discourage children from following careers "… relying heavily on manual labour or routinized service".

Ferry (2006: 4 of 6) indicates that in rural Pennsylvania it was found that, in affluent secondary schools learners seem to have more family and school support in career exploration and family members provided valuable learning experiences by becoming role models for their children.

3.4.2 Parental support and encouragement

Parents' actions can have a negative (unintentionally) or positive influence on their children's career development, and this influence is significantly strong with respect to mothers (Lessons in Learning 2007: 4 of 9). Furthermore, parents of daughters tend to believe that their child lacks interest in science or that science is more unmanageable for their daughters than for their sons. A study conducted by Foster (2005: 62) at an FET college in South Africa revealed that Black female engineering students have family members who encouraged them to follow engineering studies.

Research studies conducted by Heystek and Louw (1999) and Myeko (2000), cited by Louw (n.d.), indicated that many South African parents, especially in disadvantaged communities and rural schools, are not adequately involved in their children's learning. In a study conducted in Bloemfontein's disadvantaged schools, Louw (n.d.) found that there is a lack of parental involvement in their children's learning. Parents were found to have negative attitudes towards schools and in some cases parents reported lack of education. According to Bandura et al. (2001: 198), "… aspiring parents act in ways that build their children's academic, social, and self-regulatory efficacy, raise their aspirations, and promote their scholastic achievement". Another discouraging factor according to Liebenberg (2002: 4) is that girls do not discuss science and technology issues with their parents as much as boys do.

Parents can have a negative influence concerning careers their children want to follow. In a study conducted at The Rand Afrikaanse University (RAU), a female engineering student indicated that her mother was not happy when she announced that she wanted to study engineering. The female engineering student expressed her fears that she would not be able to marry because people would regard her as weird (Liebenberg 2002: 4).

The literature study shows that parents could be powerful forces in helping and guiding children in choosing careers. It is also evident that the educational level of parents plays a vital role in the choice of their children's career. Those children (especially Black) who find themselves surrounded by uneducated parents and family members are usually disadvantaged because they lack strong parental influences and encouragement to pursue careers in SET.

3.5 Lack of self-confidence

Halpern et al. (2007: 6) found that, generally, girls and women do not have as much confidence in their mathematical abilities as males do and this usually leads to a decreasing interest in mathematics and science careers by early adolescence, even though males and females display similar abilities in these subjects. Halpern et al. (2007: 6) indicate that theory and empirical research suggest that beliefs about abilities are key factors in determining interest and performance in different subjects as well as career choices. Foster (2005: 41) believes that confidence plays a major role in achievement, even if one has the ability, and that lack of self-confidence contributes to underachievement. Foster (2005: 41) further purports that females' under-achievement and lack of persistent participation in science and mathematics, despite their being talented in these subjects, is because of low levels of self-efficacy.

Similarly, Moletsane and Reddy (2008: 16) confirm that women in SET have displayed low confidence and that the low self-confidence might be ascribed to fears of failure or being categorised as useless. Furthermore, Lui and Wilson (2001), (in Moletsane & Reddy 2008: 16), indicate that lack of self confidence is a barrier to self development in SET. Wasburn and Miller (2004: 157) believe that lack of self-confidence in women's abilities could be due to career goals which are not well defined and this in turn makes women view college and university classes as unfriendly to them, with the result that their learning is obstructed. Monhardt, Tillotson and Veronessi (1999: 534) contend that research conducted by the Center for the Education of Women at the University of Michigan indicates that women are not confident of their abilities in science and therefore need to be encouraged to pursue careers in science. Lessons in Learning (2007: 4 of 9) confirms that girls consider science to be a difficult subject and that a possible reason could be that during middle school years girls begin to lose confidence in their abilities to learn science even though their performance does not differ significantly from that of boys. Daramola, Van den Berg and Mudondo (2002: 13) confirm that because women lack self-confidence they are fearful of taking big risks by applying for a job if they cannot perform even a few functions required for the job.

In brief, lack of self-confidence can be a barrier for women in science achievement in general, and in choosing a career in science irrespective of being gifted in the science subjects or not. Unfortunately women in general are found to be more obsessed with lack of self-confidence than men.

3.6 Practical barriers

Three practical barriers are discussed in this section, namely socio-economic factors, family circumstances and distance from HE institutions.

3.6.1 Socio-economic factors

Moloi (n.d.: 4) argues that apart from commonly known cognitive challenges that learners in general have when confronted by mathematics learning in particular, in South Africa, the apartheid government offered insufficient educational resources for Black students. Lack of sufficient educational resources in Black schools is also confirmed by Mbanga (2004: 105). Similar findings are documented in Gardner (2000: 18) in that in historically Black American schools, insufficient funds to study in SET directions were allocated by the government.

Salie (2005: 23) states that grade 12 results provide evidence that Black learners who come from economically disadvantaged families and whose social and emotive desires are not met by the existing education system, are more prone to collapse than students coming from economically privileged families. In confirmation, Macgregor (2007: 1 of 4) reiterates that Black South Africans comprise the largest group (73%) of university students with low socio-economic status (SES) while this is true of only 12% of White university students.

Reeves and Muller (2005: 105), citing the studies conducted by Howie and Hughes (1998); Joint Education Trust (2000 & 2001); and Smith (2004), document that high levels of under-performance in schools within high poverty areas are evident. And in 2004 the Western Cape outcomes of the systemic Literacy and Numeracy tests for grade 6 learners depicted a fair relationship between achievement and poverty. In addition, another study conducted by Moloi (n.d.) concerning South Africa's participation in the Southern and Eastern Africa Consortium for Monitoring Educational Quality Study (SACMEQ11) Project, it was found that students with low socio-economic status (SES) achieved more poorly than those with high SES. Sixty-five percent of low SES learners achieved SACMEQ level 1 (pre-numeracy) and 2 (emergent numeracy) which is equivalent to grade 2, 3 and lower, respectively.

Women in Science (2003-2007) documents that, in South Africa, poor families may restrict girls' access to primary and secondary schools or girls might be forced to choose less expensive subjects from the SET fields. In addition, in higher education institutions fees in SET are high and the cost of essential equipment and practical training is also high. In confirmation James, Naidoo and Benson (2008: 2) contend that lack of funding has a negative impact on the number of students who enter SET at higher education institutions in South Africa.

Researchers feel that socio-economic factors play an important role in learners' learning and achievement (Kanyongo, Certo & Launcelot 2006: 632; Bennet 2002: 3 of 20). Kanyongo et al. (2006: 632) believe that children living in poverty face developmental deficiencies that are most likely due to the inabilities of families to provide food, shelter and other necessities that foster the healthy cognitive development of children. These researchers cite studies undertaken by White in 1982 which found that there were relatively high correlations between SES and academic achievement. Similarly, Kennedy and Parks (2000: 533) indicate that the SES of learners has been found to be associated with differential participation of learners in science programs. Females and males who are in high SES homes completed more science courses than those from low SES homes.

Whilst most research has shown that, despite academic ability, most women avoid careers in SET, Teitelbaum (2001: 73 of 96) indicates that a scientific career itself is unattractive. For a scientific career, a PhD (and depending on the discipline, a post-doctoral fellowship) has become a minimum requirement. The cost of meeting these requirements are huge. Despite the long years of study it is sometimes impossible for students to practise as professionals in SET careers in contrast to careers in medicine, law and business.

3.6.2 Family circumstances

In African countries women's participation in education has been hampered by family care taking responsibilities (Bennet 2002: 3 of 20). Due to the division of labour in families and communities, household and societal conditions impact negatively on the ability of women in under-developed areas to remain on track with schooling (Brown 2006: 2 of 6). Mangena (2002: 2 of 3) accentuates that in distant rural areas of South Africa girls drop out of primary schools to take charge and look after household members. When family members become helpless through illness or old age, girls are often the first to be relegated to the caregiver status, thus compromising their chances of self development and success in education. Women in Science (2003-2007) documents that, in rural areas, girls are required to perform household chores after school while boys are free to go to computer clubs and internet cafes, and this hampers girls' exposure to Information and Communication Technology (ICT) sectors. Women in Science (2003-2007) accentuates that these household chores remain a burden throughout higher education and often result in women not completing their studies in SET disciplines which demand a lot of time. Assie-Lumumba (2006: 17) alludes to the fact that, in African communities, girls are usually faced with societal factors and values that pressurise them to leave school early and marry.

In confirmation Moletsane and Reddy (2008: 44) state that women already in SET acknowledge that because they are perceived as primary care-givers in society, they lack mobility to engage in work-related demands and undertake fieldwork. As a result they often drop out because they are unable to balance work with family commitments. As Tara Research and Equity Consultants (n.d.: 8) put it, "… the conflict between women's careers and household duties and child care responsibilities is an ongoing source of stress, time management and career planning challenges".

3.6.3 Distance from HE institutions

Another barrier to university access, especially for rural students, is the distance to HE institutions. This was reinforced by the establishment of historically Black universities and technikons (Koen 2003: 504). Technikons were regarded as institutions responsible for the development of scientific and high skilled labour. In the apartheid era (Koen 2003: 504) only four technikons for Black students were established: ML Sultan Technikon, Mangosuthu Technokin, Penninsula Technikon and the Vaal Triangle Technikon. The implication was that the majority of Black students from all corners of South Africa could not access these technikons because of their distance from their homes. When commenting on the position of Black universities and technikons in South Africa, Lickindorf (2005: 390) contends that these were located in "…remote and undesirable locations" with the purpose of discouraging Blacks from engaging in SET careers. Furthermore, Kuye (2004: 12) found that parents are usually overprotective of girls especially when they think they will live alone in a residence, with the result that girls might be discouraged to leave their homes.

In short, socio-economic factors are seen to hamper efforts of learners in general to participate adequately in SET careers and fields of study, nationally and internationally. The socio-economic status of the family, lack of funding in some schools and expensive courses in SET at higher education institutions negatively affect the engagement of Black students in particular in SET fields of study. And because of the low socio-economic status of the family and the distance from the universities, Black women sometimes find themselves unable to access higher education studies. Furthermore, household responsibilities are a burden to Black women. They usually have to balance family life and schooling or careers while men are free to engage in activities of their choices, with the result that Black women drop out of schools and universities and sometimes they are forced to abandon their careers.

3.7 Attitudes towards different vocations

Attitudes that students in general have, and continue to display towards SET careers, have been researched world-wide. The disturbing decline (as discussed in chapter 2) of learners' enrolment in SET and the under-representation of Black women in particular in SET careers and fields of study and the fact that the present scientific workforce is ageing, marks the global contemporary debates. Koballa (2008: 1 of 3) confirms that studies on learners' science related attitudes are once more gaining increased attention. Furthermore Sanfeliz and Stalzer (2003: 64) argue that learners' interests and attitudes are crucial features determining their entrance into science education. Therefore the rationale of this study is, inter alia, to explore learners' attitude to science learning.

There are many definitions of attitudes. Baron and Bryne (1991: 137 & 138) define attitudes as "… general evaluations people make about themselves, other persons, objects or issues. Attitudes reflect past experiences, shape ongoing behaviour and serve essential functions for those who hold them". Similarly, Khoo and Ainley (2005: 1) believe that student attitudes can be regarded as adaptable influences on participation because they are produced in response to curriculum, teaching practices and organisational arrangements of science. Cheung (2007) indicates that attitudes have three components: the affective (which refers to the feelings and emotions attached to an attitudinal object), the behavioural (which refers to actions towards the attitudinal object) and the cognitive (which has to do with one's beliefs about an attitudinal object). According to Cheung (2007), people have attitudes when they express love or hate or approval or disapproval towards the attitudinal object.

Baron and Bryne (1991: 141) indicate that attitudes can be created through direct and indirect experiences. Those attitudes that come from direct experiences are held more assertively and are more difficult to change than those formed through indirect experiences. Smith and Mackie (2007: 2- 3 of 4) believe that attitudes can affect behaviour in two ways: they can stimulate regular behaviours directly with little interfering thoughts, and they can also shape behaviours after wide and purposeful processing, through the forming of intentions. Smith and Mackie (2007: 4 of 4) concur that if attitudes are to direct behaviour, they must get to the mind at the appropriate time.

Furthermore, science attitudes have been seen not to be influenced by cognitive abilities only but also by non-cognitive abilities such as interests, academic attitudes, study behaviours, self-efficacy and personality factors as well (Bloye 2006: 13-17 of 111) that play a role in predicting academic performance. Citing Gardner and Tamir (1989), Trumper (2006: 48) indicates that the term 'interest' usually denotes preferences to engage in a particular type of activity rather than in others, and therefore an interest may be referred to as a highly identifiable type of attitude. With this in mind it is imperative to study the effects of these non-cognitive factors on the interests and performance of women, particularly Black women in the SET fields of study and careers.

3.7.1 Self-efficacy and motivation to learn or to achieve

Self-efficacy and motivation are elements of attitudes (Bloye 2007: 13 of 11).
Self-efficacy refers to how an individual makes an educated guess about his/her capacity to successfully engage in a particular task (Jones & Burnett 2008:50; Tuan, Chin & Shieh 2005: 641; Busch 1995: 147). Prideaux and

Creed (2001: 5) indicate that self-efficacy beliefs have been found to influence career decisions in males and females. Self-efficacy correlates, amongst others, with motivation to learn (Pajares 1996: 9 of 38). Tuan et al. (2005: 641) maintain that students with high self-efficacy are intrinsically motivated. Their goals will be directed towards satisfying their innate needs irrespective of whether the task is difficult or not. These students tend to persist in order to accomplish their goals (Pajares 1996: 9 of 38).

Studies have shown that college undergraduates with self-efficacy in mathematics are more likely to show interest in mathematics and mathematics related courses despite their previous performance in mathematics (Pajares 1996: 8 of 38). Furthermore, more males tend to report higher mathematical self-efficacy than females (Michaelides 2008: 229; Haley 2006: 13; Jones & Burnett 2008: 50). The same difference has been observed regarding male and female performance in computer programming (Jones & Burnett 2008: 50), but the only difference in this regard was that males had more experience with computer and computer games than females.

A study conducted by Foster (2005: 68) with female engineering students at an FET college in South Africa, indicates that Black females who did not enrol for engineering reported low self-efficacy in mathematics and science. These students did not perform well in mathematics and science at school level. Black females who enrolled for engineering reported high self efficacy in mathematics and science, and it was also found that they did well in mathematics and science. Osiruemu (2007: 105) believes that efficacy beliefs contribute more strongly to occupational preferences than do gender stereotyping. People with high self-efficacy usually consider a wider range of career options, while people with low self-efficacy eliminate a number of vocations based on perceived efficacy. Women are found to belong to the latter group and consider themselves as unsuitable for scientific careers. According to Halpern et al. (2007-2003: 6), theory and empirical research claims that children’s beliefs about their abilities are key determinants of their interest and performance in different subjects and finally in their career choices.

Koballa (2008: 2 of 3) refers to motivation as "… an internal state that arouses, directs and sustains behaviour". Citing studies conducted by Brophy (1988), Koballa (2008: 2 of 3) purports that motivation to learn is a student's inclination to find academic activities significant and valuable and to try to get the planned academic rewards from them. Wlodkowski (1996: 1 of 4) contends that, while motivation is an innate ability, it becomes a personality attribute largely influenced by the process of learning. According to Wlodkowski (1996: 1 of 4), "… children learn to be interested in math, fascinated by science and intrigued with art". Therefore people who are motivated to learn find ways of overcoming their obstacles in order to succeed.

In a study conducted by Tuan et al. (2005: 642) learners indicated that their motivation to learn science was due to the learners themselves, the teachers' performance and the relevance of the science content. These learners also declared that their motivation to learn is extrinsic (e.g. competition and pleasing the teachers) as well as intrinsic (satisfying their needs).

Research has indicated that as early as primary school, boys and girls show different attitudes towards science and technology, and when they reach secondary schools girls, more than boys, show a decline of interest in science and mathematics (Kahle & Damnjanovic 1997: 5; Monhardt, et al. 1999: 533; Wasburn & Miller 2004: 156; Gray 2005: 2 of 16; Trumper 2006: 47-48; Gough 2007: 6). Trumper (2006: 48) authenticates that negative attitudes towards a subject can affect learners' interests in that subject and as a result this subject can be avoided when learners have to choose their fields of study. A positive attitude towards science can result in a positive commitment to pursuing lifelong learning and eventually careers in science. Russell and Peacock (2005: 24) believe that women in general lack interest in science more than do men. These researchers indicate that attitudes and beliefs in science vary according to age, gender, education and other factors such as attitudes towards life. Various researchers have attributed these negative attitudes to science to socialisation processes which eventually lead to occupational sex role stereotypes (Haley 2007: 4-5; Gray 2005: 5 of 16).

3.7.2 Occupational Sex-role Stereotypes

Gender stereotyping is part of women's attitude towards science. Osiruemu (2007: 106) stresses that gender role is the explicit expression of attitudes that suggests to others the extent of a person's maleness or femaleness. Furthermore, gender stereotyping is an array of behavioural standards related to males and females in a specified social system. Therefore females in general have fallen prey to gender stereotyping according to which women are not supposed to fill certain occupations. This is even more so for Black women who also have to contend with racial stereotyping (Case & Jawitz 2002: 8). Case and Jawitz (2002: 8) indicates that interviews conducted with Black male and female chemical engineering 'vacation work students' in a South African University, revealed that issues of race and gender frequently interacted with experiences of being taken seriously in participating in vacation work. These students were not taken seriously and sometimes they were not regarded as potential engineers but rather as some kind of labourer because one Black male student indicates that "… he was told to make tea by a White superior, and feeling that he had no alternative but to obey this order".

Moletsane and Reddy (2008: 13) document that gender stereotypes and attitudes come from values held by families, society and media pressures as well as by the education system. All these factors play a role in determining beliefs, ideas and values. Therefore, these misguided expectations direct women to gendered classification of workers which promotes unequal distribution of women across a variety of occupations and industries.

Miller and Hayward (2006: 70) refer to occupational sex-role stereotypes as beliefs concerning the sex which should perform particular jobs and occupational sex segregation is the degree to which the workforce is actually split along gender lines in an occupation. Guimond and Roussel (2001: 278) refer to gender stereotypes as "legitimizing myths" where certain psychological processes maintain that men are dominant over women in mathematics and science.

Research results have shown that from an early age, even before attending school, females are socialised by societal beliefs "…that a woman's role is to simply serve, nurture and care" (Moletsane & Reddy 2008: 14). These stereotypes (Frehill et al. 2005: 41) are then put forward to affect girls' performance and participation in science and mathematics at school.

Studies have revealed that socialisation processes can make children internalise sex roles which influence their occupational choices. Research undertaken at the University of Minnesota (Kahle & Damnjanovic 1997: 5), documents that boys and girls learn 'gender correct' behaviour that is expected by society by 24 to 26 months of age. At that age boys and girls have already learnt stereotypical behaviours. Osiruemu (2007: 106) affirms that the progression through which individuals study socially appropriate behaviours is called socialisation. This socialisation makes children internalise sex roles which influence their occupational choices when they grow up. Kahle and Damnjanovic (1997: 5) found that boys were able to tell what they would and would not do, more so than girls. These researchers also found that when kindergarten children were interviewed three weeks after they had enrolled at school, they were not able to define science, but more boys than girls wanted to be scientists and indicated that they were good at science. These findings suggest that career choice patterns might be established as early as kindergarten age. In addition, Kennedy and Parks (2000: 532) believe that the choice of clothing, activities and toys play a major role in shaping a girl's sense of herself.

The education system can also contribute to sex-role stereotypes. Mabandla (1998: 32) feels that, in addition to racial stereotypes in the education system of the past in South Africa, there was stereotyping of women in science. Mabandla (1998: 32) states that "…instead of liberating young women and girls, education became an enslaving force". Science was seen as a man's territory, and women were regarded as incompetent to study 'difficult' scientific subjects, with the result that they were channelled to studying humanities.

Engle (2003: 6) purports that although legal obstructions to women's engagement in education and employment have been removed, social barriers are still eminent. The segregation of women and men in employment mirrors and strengthens stereotypes about gender type occupations. These stereotypes display the image of science as masculine. Knight and Cunningham (2004) contend that images are strong methods of communication and that humans construct images in order to make sense of their daily experiences. Gough (2007: 3) believes that these images can be persuasive in shaping beliefs and attitudes and can perform an important role in forming and developing identities.

3.7.2.1 Media images

Researchers have witnessed stereotypical representations of scientists in Western literature (Gough 2004: 4). In addition, Knight and Cunningham (2004) purport that the public does not have an adequate understanding of engineers and engineering as a profession. The same was discovered in a study conducted in South Africa in which educators from disadvantaged areas were requested to rate their own knowledge of the engineering profession (Horak & Fricke 2004). Haynes (in Gough 2007: 4) states that the majority of learners' representations of scientists depict scientists negatively but verifies that these depictions have not only reflected writers' opinions of the science and scientist of their era but in turn have provided a model for the current evaluations of scientists and science.

In searching present day secondary school learners' understanding, attitudes and images of science and the scientist, many different strategies have been used. A "Draw-A-Scientist Test" (DAST) has been used by researchers in science education research in order to identify the development of identity and the creation of self in the science classroom, [Reiss 1993: 19; Makate 2000: 60-62; Knight & Cunningham 2004 and Chambers (in Gough 2007: 6)].

Chambers saw a DAST as useful in identifying rather than measuring attitudes. Chambers mentions that the standard mythic images of a scientist which appeared prior to his work were the following:

- *Lab coat (not necessarily white)*
- *Eyeglasses*
- *Facial growth of hair*
- *Research symbols, e.g. laboratory equipment and instruments*
- *Knowledge symbols, e.g. books and filing cabinets*
- *Technology (the products of science)*
- *Relevant captions (formulae, taxonomic classification, etc.)* Gough (2007: 6).

According to Chambers (in Gough 2007: 6), research done on images of science and the scientist was undertaken with children, adolescents and college students. Chambers observed that the number of indicators of the traditional image of the scientist increased as the respondents became older. To ascertain if Chamber's traditional image of the scientist was still held by children and scientists, Botwell (in Gough 2007: 7) used a slightly adapted form of the DAST, a questionnaire and an interview. Little differences were found because although grade 5 and 6 students portrayed stereotypical images of scientists, interviews showed that scientists were viewed as ordinary people. Secondly, the study reported that adults and scientists usually put forward illustrations of stereotypical images of the scientist including Chamber's indicators of a scientist. Furthermore, children have a tendency of portraying few women as scientists as reflected from the DAST.

Similar findings were attained in a DAST in a primary school in the Xhariep district in the Free State (Makate 2000: 60-62). The researcher's aim was to determine gender inequities in science education. In grade 4 drawings, 94.3% of boys' drawings were of males while only 5.7% were of females. Ninety-three comma six percent of girls' drawings resembled females, while 6.4% resembled males. It was evident that the learners portrayed themselves (or persons of the same gender) in their drawings. Furthermore, other features of scientists according to their drawings, dealt with maps, weather, flying aeroplanes as well as a few drawings of female doctors and nurses. Most of the drawings, however, indicated that learners did not know exactly what a scientist is and does. It was also evident that many of them had never seen pictures of scientists in books before.

In a study conducted by Makate (2000: 60-62) it was found that most of the grade 5 learners depicted a scientist as male (84.2 % of boys and 68.8% of girls seemingly held these perceptions). In respect of grade 6 learners, however, boys predominantly depicted scientists as male while girls depicted scientists as females. From these results it was deduced that the differences between grade 5 and 6 girls' responses could be due to the fact that the selected grade 5 class was taught by a male educator, while the grade 6 class was taught by a female educator. It thus seemed that, for learners with limited knowledge and experience, scientists resembled their own educators. Similar findings were reported by Knight and Cunningham (2004) with grades 9 to 12 learners in Boston. Results indicated that females were more likely to draw female scientists than males. Most of these drawings came from classes which were taught by two female undergraduate engineering students from Tufts University who had been teaching learners for a few months.

A study conducted in England by Miller and Hayward (2006: 85), examined the influence of occupational sex-role stereotypes and perceived gender segregation in regard to job preferences in learners aged 14 to 18 years. Boys preferred jobs that they believed should be carried out by boys and girls preferred jobs that they believed should be executed by girls. For girls these beliefs notably moderated with age. The relationship between the liking of the job and the assumed gender segregation and stereotypes, moderated between the ages of 16 and 17 and disappeared gradually by the time girls reached the ages of 17 and 18. For boys the relationship remained substantial between the ages of 14 to 18 and did not weaken at all. By the time women start to think fully about a wide range of jobs as appealing options (17-18 years), crucial decisions about qualifications would have already been completed, impeding the real alternatives available to them (Miller & Hayward 2006: 85). This study also examined the impact of both occupational sex-role stereotypes and occupational sex segregation. The data revealed that views of occupational sex-role stereotypes (who should do the job) change with age but views on the extent to which an occupation is gender segregated (what is the case really in the actual working environment) do not.

From these findings Miller and Hayward (2006: 86) conclude that stereotypes are systems of beliefs which are subject to correction as the child's world-view fully develops, while estimates of gender segregation are based on comparatively true perceptions of the working environment, which are difficult to change unless the environment itself changes.

A study conducted in Australia by Gough (2007: 11) discovered that secondary school learners acknowledge the importance of science and technology for society but do not regard themselves as part of it. They are not interested in studying science at secondary school or pursuing careers in science.

Klawe (2000: 61) indicates that television is of particular importance in shaping children's attitudes and behaviours. In America children's television programs have been found to propagate the stereotype of the scientist as male and images are usually negative and incorrect. Klawe (2000: 63) found that 75 percent of the scientists on prime time television were White males. Her studies concluded that if children go along with examples from television, there will be hardly any females and other minorities in science occupations in future.

Hamilton, Anderson, Broaddus and Young (2007: 1 of 13) confirm that gender discrimination in picture books is detrimental to children. Hamilton et al. (2007: 2 of 13) indicate that female characters are still under-represented in children's picture books and that these stereotypical portrayals of the scientist contribute negatively to children's advancement. These stereotypes (Hamilton et al. 2007: 1 of 13) further restrict their career choices, construct their attitudes about their imminent roles as parents and manipulate their personality characteristics.

Research indicates that women experience problems in science classrooms. Those women who managed to survive the uninviting science classrooms and enter the scientific community still find it difficult to cite their work as scientific even if their education and professional practices are based on scientific principles. These women (Liebenberg 2002: 3) may silently abandon the profession. Women's work in the sphere of health care, even when shown to be organised, meticulous and valuable, is rarely labelled as science. Women's work in the traditional scientific male dominated fields, have also been overlooked (Bebbington 2002: 366). In confirmation, Gray (2005: 6 of 16) indicates that there is lack of acknowledgement of contributions and accomplishments of women in scientific textbooks and a lack of female educators and professors in the sciences. This indicates that female achievements in science are often ignored or marginalised.

Occupational segregation has been noticed in the labour market. A study undertaken in the United Kingdom includes some evidence that women in SET occupations have difficulty in merging the competing demands of professional and family life and that these conflicts are marked for women in traditionally male dominated occupations (Bebbington 2002: 364).

Monhardt et al. (1999: 534) cite the research done by Kubanek and Waller (1995) who found that younger women, unlike their male counterparts, were indecisive about choosing a career in science because of the 'superwoman' image that is obligatory when managing a science career as well as a family. In this regard Ferganchick-Neufang (1998: 5 of 14) states that women are constantly asked to prove themselves because the social order continues to think that the "…weaker sex extends past physical ability and into mental ability".

Rayman (2001: 65 of 96) indicates that the culture of science is based on aggressive behaviour and is gender biased. Rayman (2001: 65 of 96) feels that this type of climate has succeeded in attracting and retaining males, who thrive under such conditions, and disposed of those who do not thrive. On the other hand, gender specific socialisation typifies women to be less competitive, less self-driven, more relational and more apt to have multiple role identities (care-givers and scientists). It is this culture which drives women away.

Halvorsen (2002: 347) distinguishes between a “Knowledge Society” and a “Professional Society”. In a “Professional Society” expertise is found in the professional elite (e.g. lawyers and doctors), whereas a “Knowledge Society” is the one in which education which can enhance expertise is within reach of and available to everyone. Halvorsen (2002: 347) believes that the distribution of knowledge leaves out part of the population based on predetermined social prescripts such as gender, class and ethnicity. Reference is made to the UK where even though the “Professional Society” is being eroded, traces of a masculine culture are still universal. On this note Halvorsen (2002: 355) feels that women are likely to continue to be disadvantaged with regard to their employment, promotion opportunities and appointments to permanent positions despite a shift from a “Professional” to a “Knowledge-based” Society.

Furthermore, Teitelbaum (2001: 77-78 of 96) states that a scientist will be 35 to 40 years of age before obtaining his or her first permanent job. Those in search of academic careers must spend 6 years of conditional appointment as assistant professors. As a result a stable appointment can be achieved at about 31 years of age for mathematics and about 40 years of age or older for the life sciences. When comparing careers in engineering, with careers such as medicine, law or business, a graduate can acquire full professional status at about the age of 28 for medicine, and the age of 26 for business and law. It is likely that fields in which a career cannot be firmly established before the middle or early 30s can place special stress upon women who want to be married and have children.

3.8 Influence of role models

Monhardt et al. (1999: 539) believe that mentoring or the lack of a mentor influences career choices of women. In their study these researchers found that women scientists indicated that they were handicapped in pursuing their careers because of lack of information and encouragement that might have assisted them to advance professionally. Research has indicated that SET careers endorse a masculine territory (Disken 2000: 51). Because of this it might be difficult for women to find mentors like men do since individuals find it easier to mentor people who are like themselves. Tara Research and Equity Consultants (n.d.) indicate that women prefer women mentors in the hope of finding a compassionate mentor because they need a sympathetic relationship.

Lack of role models has been found to influence career choices of learners. De Santis, (2006: 2) defines role models as "… people whose lives and activities influence another person in some way". Studies conducted by Brownlow et al. (2000: 121) document that adult role models do influence children's beliefs about appropriate careers. De Santis (2006: 2) states that since children are more likely to engage in activities similar to those of their gender or race, girls find themselves not having enough role models in SET careers and fields of study because there are few women scientists. Citing research done by Gilbert (1985) and Smith and Erb (1986), De Santis (2006: 2) further indicates that students regard role models as important for women who want to follow non-traditional careers.

Similarly, Foster (2005: 40 - 41) documents that there are few women educators who teach science and technical subjects at secondary schools and higher education institutions and therefore females have little chance of being influenced by them. In addition, lack of same sex and same race educators impacts negatively at secondary school as well as in tertiary institutions. In the absence of role models women are anxious about ways of dealing with their problems.

Peers are also found to play a role in career aspirations of adolescents. Foster (2005: 44) notes that not much research has been done on the influence of peers on careers, but studies undertaken show that adolescent boys and girls have an influence on the career choices of other adolescents in SET. Foster (2005: 44), citing studies conducted by Baker and Leary (1995), indicates that girls show more positive attitudes to careers in SET when they have a friend studying SET, and have fewer stereotyped views concerning science and science related fields. A study conducted by The Center for Women and Work and The John Heldrich Center for Workforce Development (2002: 6 of 28), indicates that when workers were asked who encouraged them in their current jobs they indicated that they were encouraged by their friends.

3.9 Conclusion

In this chapter several factors influencing vocational choices of Black women have been discussed. It has been shown that there are cognitive and non-cognitive factors that might influence career choices of Black women. Furthermore, there are also very practical factors including socio-economic factors, family circumstances and the distance from HE institutions which might also inhibit Black females from pursuing SET studies in HE. Another factor might be lack of role models which can be an educator, a parent, peers or any other person that might influence Black girls to enrol in great numbers in SET.

To conclude, research results authenticate that attitudes play an important role in occupational choices of adolescents. Children's attitudes towards SET careers are influenced by a variety of factors, such as self efficacy, interest and motivation. Gender stereotyping is found to be an explicit type of attitude towards science related fields according to which women should not choose scientific careers. These attitudes are formed because of experiences and societal beliefs about the expected roles of males and females. The function of socialisation promotes desirable and suppresses undesirable behaviour. Therefore women in general, and Black women in particular, are the ones who will most probably stay invisible in the SET fields of study and careers unless societal beliefs change.

The empirical research undertaken in this study specifically focuses on two factors possibly influencing career choices of Black women in SET, namely, attitudes and occupational sex-role stereotypes towards the natural sciences. In the next chapter the research design and methodology employed in the research are discussed.

CHAPTER 4

METHODOLOGY

4.1 Introduction

Chapter 2 provided a hypothetical background to the under-representation of Black women in SET fields of study and workplaces. The literature review provided statistics which show that Black women in particular do not perform well in science subjects at school (especially mathematics and physical science). These may be contributing factors to the grossly under-representation of Black females in SET fields of study and careers in HE institutions (see 2.2.8).

In Chapter 3 possible factors were considered that might affect career choices of women in general and Black women in particular. A conclusion was drawn that amongst many factors cited in the literature, it was necessary to investigate the attitudes and occupational sex-role stereotypes of Black women in the natural sciences in a specific South African context. In this way a contribution could be made to knowledge production in the fields of education/higher education in particular, in the sense of a better understanding of why Black females are under-represented in SET fields. This should be regarded as the overall goal of the study. Such knowledge could ultimately pave the way for measures by means of which the problems could be appropriately addressed.

This chapter is particularly concerned with the research design and the appropriateness of the different kinds of research methods employed in the particular study. It further aims to describe the conditions under which the methods were used for different kinds of data collection, analyses and reporting.

The study must be seen against the research problem, as argued in chapters 1, 2 and 3, and as summarized below.

4.2 Statement of the research problem

The research problem in this study centres on the problem of under-representation of Black females in SET and most often, lower achievement of these females in most instances. Many factors might possibly contribute to the situation, including sex-role stereotypes and females' attitudes regarding the natural sciences (see 3.6). In South Africa, factors contributing to the under-representation are not well known and not extensively researched, in particular in rural areas. In the light of this the general research question that gave rise to this research can be stated as follows:

Is there a relationship between science attitude and occupational sex-role stereotypes among rural Black females and the entrance into natural sciences studies in Higher Education?

The criterion for entrance into natural science studies will be the marks of grade 12 rural Black females obtained in the subjects: biology, physical science and mathematics, combined with the results obtained from Entrance Tests in many HE institutions as stipulated by HESA. Therefore the specific research question is as follows:

Is there a relationship between science attitude and occupational sex-role stereotypes among rural black females and marks in biology, physical science and mathematics?

The research question gave rise to the following hypotheses.

4.3 Hypotheses

The null hypothesis 1: *There is no relationship between science attitude and marks of rural Black females in biology, physical science and mathematics.*

The alternative hypothesis 1: *There is a positive relationship between science attitude and marks of rural Black females in biology, physical science and mathematics.*

The null hypothesis 2: *There is no relationship between occupational sex-role stereotypes and marks of rural Black females in biology, physical science and mathematics.*

The alternative hypothesis 2: *There is a positive relationship between occupational sex-role stereotypes and marks of rural Black females in biology, physical science and mathematics.*

The hypotheses will be tested using a 0.05 level of significance.

4.4 Aims of the study

The aim of the study was to investigate the relationship between science attitude and occupational sex-role stereotypes and marks in biology, physical science and mathematics of rural Black females.

4.5 Identifying the variables

The nature of the independent and dependent variables are discussed in this section.

4.5.1 Independent variables

The two independent variables in this study are science attitudes and sex-role stereotypes

4.5.1.1 Science Attitudes

Pasquier, Rahwan, Dignum and Sonenberg (2003: 5) refer to attitudes as constructive or destructive psychological dispositions towards a real or imaginary object or behaviour. Pasquir et al. (2003: 5) further indicate that attitudes are important elements of cognition and that "… the beliefs (cognition) and desires (affect) lead to intentions which could lead to actual behaviours or dialogical attempts to get the corresponding social commitments depending on their nature".

For the purpose of the study the operational definition of science attitude will be described as the score obtained from the Science Attitude Scale for Middle School learners (Appendix A Section B).

4.5.1.2 Occupational Sex-role Stereotypes

Occupational sex-role stereotypes are beliefs concerning which sex should perform certain jobs (Miller & Hayward 2006: 70). Guimond and Rousell (2001: 278) purport that these stereotypes operate as "legitimizing myths" which can activate certain psychological processes that will play a role in upholding the status of men as having authority over women in mathematics and science.

The operational definition of Occupational Sex-role Stereotypes in this study is described as the score obtained from the job stereotype questionnaire (see appendix A section C)

4.5.2 Dependent variable

The dependent variable in this study is academic achievement, as explained below.

Academic achievement in biology, physical science and mathematics

Bloye (2007: 16 of 111), in reference to Kobal and Musek's (2001) definition indicates that academic achievement has to do with the numerical points of a learner's knowledge, indicating a level of a learner's adjustment to school work and the educational system.

For the purpose of this study, academic achievement will be defined as the marks in biology, physical science and mathematics as obtained from the grade 11 November 2008 results only. It was impossible to get marks for the June 2009 results because some schools did not write the grade 12 June 2009 examinations.

The operational definition of academic performance is described as the marks obtained in biology, physical science and mathematics as reflected in the grade 11 November 2008 results.

The confounding variables identified in the study are described in the next section.

4.5.3 Confounding variables

Confounding variables can also be referred to as extraneous variables or intervening variables (Wright & Lake 2006: 5 of 15). If not controlled, these factors can influence research results. To ensure that research results are not confounded, confounding variables were built into the design, measured and analysed to determine whether they have a significant effect on the dependent variables or not. The confounding variables in this study are:

4.5.3.1 Ethnicity

The American Anthropological Association (1997: 3 - 6 of 9) indicates that ‘race’ and ‘ethnicity’ are not clearly distinct concepts. Prevalent connotations of ‘race’ tend to be related with physiology and those of ‘ethnicity’ with culture. Ethnicity may be defined as the classification of the population groups which are distinguished by common ancestry, language and custom. Ethnic groups often share physiology, which become part of their identification.

For the purpose of the study, to be operationally defined, ethnicity will be measured as a categorical variable.

4.5.3.2 Psychosocial background factors

The term ‘psychosocial’ is widely used in literature in the context of health research and social epidemiology. Psychosocial factors can be regarded as influences acting mainly between the social (effects of social factors) and the individual (the individual’s mind or behaviour) level and to the interrelatedness of behavioural and societal factors (Martikakeinen, Bartley & Lahelma 2002: 2 of 7).

For the purpose of the study, psychosocial background factors will be operationally defined as a score on the Scale measuring Psychosocial Background Factors (see appendix A section D).

The research design and methodology employed in the study are discussed below.

4.6 Research design and methodology

A quantitative research design was regarded mostly appropriate to conduct this multivariate empirical study. Since non-experimental research designs use types such as descriptive, correlational, ex post facto and survey research (McMillan & Schumacher 1993: 266-293), a non experimental research inferential multivariate research design in the form of a survey was employed. The rationale for choosing a survey research is that “… most surveys describe the incidence, frequency and distribution of the characteristics of an identified population”. “… surveys can also be used to explore relationships between variables, in an explanatory way” (McMillan & Schumacher 1993: 280)

Furthermore, a quantitative design, as stated by Kellinger (1986: 10), the renowned author in the field of research methodology, refers to “…a systematic, controlled, empirical and critical investigation of natural phenomena guided by theory and hypotheses about the presumed relationships among such phenomena. This study could determine whether there is a correlation between science attitudes and occupational sex-role stereotypes and marks in biology, physical science and mathematics.

4.6.1 The test group

The target population was all Black females in grade 12 in the Xhariep district. However, only grade 12 Black females from 5 schools were selected for the sample. Sampling of institutions and respondents took place purposefully and conveniently. Sampling comprised 112 grade 12 females from the rural parts of the Xhariep district in the Southern Free State province of South Africa. Participants were selected on the basis of proximity of schools and informed consent from the Department of Education, principals and students. Because of the vastness of the Xhariep district, small towns which are far apart from each other and small grade 12 classes, it was impossible to obtain a large sample. The schools were similar because they were all Black township schools.

Sample inclusion took place according to the following criteria:

- Grade 12 – 2009 enrolments;
- Gender – only females;
- Ethnicity – all African;
- Language – all African languages;
- English as medium of instruction; and
- Informed consent from participants.

4.6.2 Data collection

Permission was granted to gain access to 5 secondary schools in the Xhariep rural areas of the Southern Free State. Participants were gathered in the school hall and the letter of consent was read to participants in the presence of an educator who was assisting the researcher. Participants were requested to ask questions if there was anything they wanted clarity on before they signed the consent forms. The educator also signed as a witness that participants were not forced to participate in the study.

Before the instruments were administered, the researcher explained what was required of the participants and how to complete the instrument. The questionnaire was divided into sections. In Section A participants had to provide their biographical information. Section B was a questionnaire on the Science Attitude Scale for Middle School learners. The six point scale questionnaire ranged from ‘completely disagree’ to ‘completely agree’. Participants were requested to indicate their responses by making a cross in the box of their choice. Section C was a questionnaire measuring Job Stereotypes. The six point scale questionnaire ranged from ‘completely disagree’ to ‘completely agree’. Participants had to indicate their responses by making a cross in the appropriate block of their choice. The last section measured the Psychosocial Background factors of learners. Participants had to rate the given aspects of their lives by marking the block closest to the description of that aspect on a six point scale. The scales were scored and handed to the statistician for analyses of results. Marks in biology, physical science and mathematics were obtained from the grade 11 November 2008 results.

4.6.3 Research instruments

For the purpose of the study the following instruments were used:

- The Science Attitude Scale for Middle School Students;
- The scale measuring Occupational Sex-role stereotypes; and
- The scale measuring the Psychosocial Background factors of students.

4.6.3.1 The Science Attitude Scale for Middle School Students (adapted)

The scale has been used among American middle school learners over the past two decades and completes the composition of three generations of instrument development (Misiti, Shrigley & Hanson 1991: 525). Initially the scale was a 33-item Likert scale designed for grade 6 students in which the effects of "handmade and commercial science equipment" on the attitudes towards science were measured. Misiti et al. (1991: 525) confirmed that the scale lacked validation ratings.

The second generation redesigned the scale to test science attitudes of a number of grade 4, 5 and 6 students whose teachers were engaged in a district in-service project for three years. The scale was never published. After many years many researchers applied for permission to use it. Mohammed Salim translated it into Arabic and administered it to grade 5 Egyptian students. The scale consisted of 14 positive and 13 negative statements. Later it was administered to 70 grade 4 and 102 grade 5 students. The coefficient alpha for the two sets of data was 0.86.

According to Misiti et al. (1991: 527), the third generation of instrument development, which informed procedures for revisiting the scale, is the work of Koballa (1984); Abdel-Gaid et al. (1986); Thompson et al. (1986) and Calhoun et al. (1988). These researchers suggested that if the scale is amended it should be published. In this scale validation procedures not mentioned by the scales cited earlier were tried. Procedures included calling middle school children into the jury process, trying out the scale for evaluative quality and cross-cultural examination. The target population comprised grades 5, 6, 7 and 8 learners. Twenty-three Likert type items were ultimately chosen with the following subcomponents:

Subcomponent 1: Investigations – eight items

Subcomponent 2: Comfort/discomfort – six items

Subcomponent 3: Learning science content – four items

Subcomponent 4: Reading and talking about science – three items

Subcomponent 5: Viewing films on TV – two items (Misiti et al. 1991: 533).

The data generated from 206 subjects on 23 items and from 109 middle school learners on the same items produced coefficient alphas of 0.96 and 0.92 on both sets of data respectively, convincingly suggesting interconnectedness of the items (Misiti et al. 1991: 534).

The rationale for using the Science Attitude Scale for Middle School Students is that researchers, including Misiti et al. (1991: 525), claim that it is during these years (late primary) in which attitudes that influence the choice of science courses at secondary schools and colleges are formed. And because the scale has passed a number of tests for validity it could be used with secondary school learners (Misiti et al. 1991: 538). Therefore it was considered applicable to grade 12 students because the respondents in this sample were English second language speakers.

4.6.3.2 The Scale measuring Occupational Sex-role Stereotypes

Miller and Hayward (2006: 74) designed a questionnaire based on the one used in Miller and Budd (1999). The scale was extended to take into account the extent to which occupational gender segregation and occupational sex-role stereotypes influence young people's liking for, and knowledge of, jobs. In the first section for each of the 23 listed jobs, learners were requested to rate their job knowledge. In the second section, the questionnaire provided a short definition of each occupation in which subjects were asked three questions in order to assess the extent to which a job was viewed as stereotyped; the extent to which a job was gender segregated, and lastly preferences or liking of the job. The scale was administered to 222 girls and 286 boys in England between the ages of 14 and 18.

For the purpose of this study only the section measuring occupational sex-role stereotypes was used. The scale was modified and only a list of non-traditional occupations was used in which a short definition of each occupation type was given. Furthermore, the test was only administered to girls. The Cronbach Alpha of the scale as used in this study was 0.95. The scale has obvious construct validity.

4.6.3.3 The Scale measuring Psychosocial Background factors of learners

The psychosocial background factors questionnaire is divided into four subsections measuring emotional support, socio-economic situation, environment conducive to learning and depression. Participants were required to make a cross in the box closest to the description of the aspect. The scale was developed by Viljoen (2007) and has a Cronbach Alpha of 0.83 which is satisfactory for internal consistency. The questions of the scale indicate that it has construct validity.

The following section concerns the analyses of data.

4.6.4 Analysis of results.

Data analyses was done by Professor Schall of the Department of Statistics at the University of the Free State using descriptive univariate and multivariate analyses. The data analysis plan provided by Prof. Schall (2009) (Appendix C) was used.

4.6.4.1 Objective of statistical analysis

The principal objective of statistical analysis is to explore the effect of science attitude and job stereotypes on science marks, while controlling potential confounders such as age, ethnicity and psychosocial background factors.

4.6.4.2 Descriptive analysis

Frequency tabulations (number of learners and percent of learners per category) for the following variables will be presented. The Statistical Analyses Plan of Professor Schall (2009) is used verbatim in this section.

- *Ethnicity*

Software*: SAS Proc FREQ.*

Descriptive statistics (mean, SD, median, mean, max, number of observations) will be presented for each quantitative variable, namely

- *Score on Science attitude scale for middle school children*
- *Score on Job stereotypes*
- *Marks in biology*
- *Marks in physical science*
- *Marks in mathematics*
- *Age*
- *Psychosocial background score*

Software: *SAS Proc MEANS*

4.6.4.3 Univariate analysis

The three dependent variables are the following:

- *Marks in biology*
- *Marks in physical science*
- *Marks in mathematics*

Each dependent variable will be analysed using one-way ANOVA fitting the categorical confounding variable:

- *Ethnicity*

Each dependent variable will be analysed using simple linear regression fitting (one at a time) of the following variables:

- *Score on Science attitude scale for middle school children*
- *Score on Job stereotyping*
- *Age (continuous)*
- *Psycho-social background score (continuous)*

Software: *SAS Proc GLM*

4.6.4.4 Multivariate analysis

Each independent variable will be analysed using linear regression and analysis of covariance techniques. Initially, the analysis of a covariance model for each dependent variable will contain the two independent variables (score on Science attitude scale for middle school children and score on Job stereotyping) and all potential confounders (age, ethnicity and psychosocial background score) F-statistics and associated P-values will be calculated for each variable in the model. Stepwise model selection will be applied by removing, one at a time, that variable among the confounders which is least significantly associated with the outcome, providing that the P-value is at least 0.1.

Software: *SAS Proc GLM* (Schall 2009).

4.7 Reliability and validity of the research

4.7.1 Reliability

In quantitative research reliability is determined by the reliability of the measuring instruments and applying the correct statistical techniques. McMillan and Schumacher (1993: 227) define reliability as the constancy of measurement, the degree to which similar results are reported over different forms of the same instrument or instances of data collecting. Trochim (2006: 1-7 of 7) states that there are four types of reliability estimates, namely Inter-Observer Reliability, Test-Retest Reliability, Parallel-Forms Reliability and Internal Consistency Reliability. For the purpose of this study Internal Consistency Reliability estimates were used. In internal consistency reliability estimation, a single measurement instrument is administered to the target population on one instance to measure reliability. The reliability of the instrument is ascertained by estimating how the items that show the same construct produce consistent results

(Trochim 2006: 3-4 of 7). Since the Cronbach Alpha of the scale measuring science attitude was 0.96 and 0.92 on both sets of data respectively (4.6.3.1), 0.95 on the scale measuring occupational sex-role stereotypes (4.6.3.2) and 0.83 on the scale measuring psychosocial background factors (4.6.3.3), the scales have proven reliability. According to Trochim (2006: 6 of 7) "… Cronbach's Alpha tends to be the most frequently used estimate of internal consistency". Santos (1999: 2 of 4), citing Nunnaly (1978) indicates that 0.7 is an acceptable reliability coefficient.

Furthermore the instruments used were at the appropriate reading level and language of grade 12 learners. All respondents were given the same directions, answered the questionnaire within the same time frames at the same time during the day (McMillan & Schumacher 1993: 230-231). Because the questionnaires and scales have proven reliability, the reliability of the research is assumed.

4.7.2 Internal validity and external validity

Mcmillan and Schumacher (1993: 223) indicate that validity is a judgement of the correctness of the measure for exclusive decisions that emanate from the scores that result from the study. Lee (2007: 61), drawing on Pedhazur and Schmelkin (1991), refers to internal validity as the validity of results concerning the effects of the independent variable(s) on the dependent variables. Internal validity (McMillan & Schumacher 2006: 118) controls confounding variables by building a possible confounding variable into the design as another independent variable. Therefore Maas (1998: 24) refers to internal validity as the degree to which variations in the dependent variable are accounted for by differences in the independent variable and not by any extraneous or third variable. Because extraneous variables were measured and accounted for as far as possible, internal validity was obtained.

External validity, on the other hand, is the degree to which results of the study can assertively be generalized to the population from which the sample was drawn

(Kellinger 1986: 300). Because random sampling was not done in this study, external validity cannot be claimed.

4.8 Conclusion

This chapter explained the methodology employed in the study. The statement of the research problem was presented followed by the underlying hypotheses. The aims and the objectives of the study were presented and the independent, dependent and confounding variables were identified and operationally defined. A quantitative research design approach was presented in which information regarding the test group, data collection procedures and the research instruments was provided. The data analyses plan was highlighted in which a descriptive univariate and multivariate analyses were used to analyse the data. Reliability and validity of the research was presented. The results of the present study are reported and discussed in the next chapter.

CHAPTER 5

RESULTS AND DISCUSSION OF RESULTS

5.1 Introduction

The primary objective of the statistical analysis was to determine whether there was a relationship between science attitudes, occupational sex-role stereotypes and academic achievement in biology, physical science and mathematics of 112 grade 12 rural Black females. The respondents completed a six point scale questionnaire measuring science attitudes, job stereotypes and psychosocial background factors. In the first section of the questionnaire respondents were required to fill in their biographical information. Academic achievement was measured in terms of marks in biology, physical science and mathematics. A discussion of the research results will be presented in this chapter.

5.2 Descriptive Analyses

5.2.1 Descriptive analysis: Categorical confounding variables

The only categorical variable is ethnicity.

Table 1: Ethnicity of respondents in the sample

Description	Frequency	Percentage	Cumulative Percentage
S. Sotho	67	63.21	63.21
Xhosa	39	36.79	100.00

The data collected indicate that there were 67 South Sotho learners in the sample, which amounted to 63.21 percent. There were 39 Xhosa learners with a percentage of 36.79. The cumulative percentage of the test group was 100.00.

5.2.2 Descriptive analysis: Continuous confounding variables

The continuous confounding variables are age and psychosocial background factors.

Table 2: Age and Psychosocial Background factors.

Variable	N	Mean	Std Dev	Minimum	Maximum	Median
Age	112	19.11	1.47	17.00	23.00	19.00
Psychosocial factors	112	31.05	12.31	14.00	71	29.50

There were 112 respondents in the test group. Research results indicate that the mean score of the respondents was 19.11, the standard deviation was 1.47. The minimum age of the respondents was 17.00, the maximum age was 23.00 and the median was 19.00. The table shows that there were students between 20 and 23 years of age in the test group. These students are regarded as old to be in grade 12.

112 respondents completed the psychosocial background questionnaire. The mean score was 31.05, the standard deviation was 12.31, the minimum score was 14.00, the maximum score was 71 and the median was 29.50.

The independent variables are science attitude and occupational sex-role stereotypes.

Table 3: Descriptive analysis continuous independent variables: Science Attitude and Occupational Sex-role Stereotypes

Variable	N	Mean	Std Dev	Minimum	Maximum	Median
Science A	112	65.45	15.91	23.00	111.00	66.50
Job S	112	106.96	21.73	30.00	138.00	108.00

Regarding the science attitude, 112 students completed the questionnaire. The mean on the science attitude scale was 65.45, the standard deviation was 15.91, the minimum score was 23.00, the maximum score was 111.00 and the median was 66.50.

Concerning the job stereotype scale, 112 students completed the questionnaire. The mean on the job stereotyping scale was 106.96, the standard deviation was 21.73, the minimum score was 30.00, the maximum score was 138.00 and the median was 108.00.

The dependent variables are biology, physical science and mathematics.

Table 4: Descriptive analysis continuous dependent variables: biology, physical science and mathematics.

Variable	N	Mean	Std Dev	Minimum	Maximum	Median
Biology	44	37.80	7.50	24.00	55.00	38.00
Physical Science	33	39.85	7.13	24.00	52.00	40.00
Mathematics	38	33.24	10.82	15.00	64.00	32.50

44 respondents in the study took biology as a subject. The mean mark was 37.80, the standard deviation was 7.50, the minimum mark was 24.00, the maximum mark was 55.00 and the median was 38.00.

33 respondents in the study took physical science as a subject. The mean mark was 39.85, the standard deviation was 7.13, the minimum mark was 24, the maximum mark was 52 and the median was 40.00.

38 respondents in the test took mathematics as a subject. The mean mark was 33.24, the standard deviation was 10.82, the minimum mark was 15.00, the maximum mark was 64.00 and the median was 32.50.

5.3 Analyses of association

The relationship between the dependent variables and the independent variables will now be reported and discussed firstly, by using univariate and then a multivariate analysis. There are two independent variables, namely science attitude and occupational sex-role stereotypes which are presented by continuous scores on two questionnaires (see chapter 4). The dependent variables are marks in biology, physical science and mathematics.

The table below gives the relationship between science attitude, job stereotypes and marks in biology as analysed by means of univariate analysis t-test.

Table 5: t-test for the relationship between Science Attitude, Job Stereotypes and marks in biology.

Variable	Standard Error	t-value	p-value
Science A	0.08749270	-0.72	0.4755
Job S	0.05913645	0.61	0.5445

The data shows that there is no significant relationship between science attitudes, job stereotyping and biology because both p-values are greater than 0.05. The null hypothesis is accepted.

The relationship between science attitude, job stereotypes and marks in physical science was analysed using univariate analysis t-test.

Table 6: t-test for the relationship between Science Attitudes, Job Stereotypes and marks in physical science.

Variable	Standard Error	t-value	p-value
Science A	0.11360291	0.92	0.3633
Job S	0.06035183	1.02	0.3161

The results show that there is no significant relationship between science attitude, job stereotypes and marks in physical science, because both p-values are greater than 0.05. The null hypothesis is accepted.

The relationship between science attitude, job stereotypes and scores in mathematics was analysed using univariate analysis t-test.

Table 7: t-test for the relationship between Science Attitudes, Job Stereotypes and marks in mathematics.

Variable	Standard Error	t-value	p-value
Science A	0.13757737	-0.97	0.3388
Job S	0.08695481	0.46	0.6458

The results indicates that there is no significant relationship between science attitudes, job stereotypes and marks in mathematics, because both p-values are greater than 0.05. The null hypothesis is accepted.

Because all three of these alternative hypotheses were rejected and the null hypotheses accepted, it was decided to analyse the independent variable, that is science attitudes and job stereotype, against science marks (which is the total of the three subjects: biology, physical science and mathematics). These results will now be reported.

Table 8: Descriptive statistics dependent variable science marks.

Variable	N	Mean	Std Dev	Minimum	Maximum	Median
Science marks	33	112.00	18.56	79.00	142.00	113.00

Out of 112 learners only 33 took all three subjects in grade 12. The mean mark was 112.00, the standard deviation was 18.56, the minimum mark was 79.00, the maximum mark was 142.00 and the median was 113.

The relationship between science attitude, job stereotypes and science marks was calculated and reported in table 9.

Table 9: The relationship between Science Attitude, Job Stereotypes and science marks.

Variable	Standard Error	t-value	p-value
Science A	0.29690875	0.78	0.4409
Job S	0.15899374	0.54	0.5923

The data show that there is no relationship between science attitude, job stereotypes and the total science marks in biology, physical science and mathematics. Both the p-values are greater than 0.05.

The results indicate that these learners did not perform well in all three subjects in grade 11. Although a longitudinal case study of the respondents was not carried out to track performance of these learners in science, the literature review suggests that gender differences in science achievement develop during secondary school years (see 3.2). Females in general do not perform equally well in science (especially in mathematics) when compared to their male counterparts (see 2.2.5). Despite the fact that this study did not compare the achievements of males and females in these subjects, the results show that Black females in the study did perform badly in science and in science subjects. This is in accordance with the results of other studies (see 2.2.8). Furthermore, studies indicate that matriculation results cannot be regarded as a true reflection of academic ability (see 3.2). Therefore it cannot be concluded that these female learners do not have an aptitude for science.

Research undertaken by Bernstein (2007: 37) revealed that in South Africa, in many cases, primary school teachers have a limited content knowledge of mathematics and science. This implies that students from the primary schools reach the secondary school level being inadequately prepared in these subjects. In addition, Woollacott and Henning (2004: 3) argue that the University of the Witwatersrand in South Africa is usually faced with the problem of under-preparedness of first year engineering entrants. These researchers view under-preparedness as a situation in which the knowledge and competencies of the student enrolling for an educational program relates negatively to the knowledge and competencies on which the program is based, which students are supposed to have acquired at the secondary school level. Therefore the student's innate ability may be beset by inadequacies in knowledge, skills and academic expertise. These students are likely to achieve below their potential and will be unsuccessful even if they may have the ability to succeed.

The literature review undertaken documented that females in general have negative attitudes towards science (see 3.7). Added to negative attitudes towards science, females have been noted to hold stereotypical views of male dominated science careers (see 3.7.2). The results of the study show that the average for both science attitude and occupational sex-role stereotypes is slightly elevated. Polit and Beck (2008: 564) indicate that the median can be used to understand what the typical test score of a respondent is. Thus, when analysing the descriptive results it is evident that a typical student does not have a negative attitude towards science or hold stereotypes of jobs in this field. In this regard Halpern et al. (2007: 6) indicate that students' beliefs about their abilities are crucial determinants of their interest and performance in different subjects.

In light of the above discussion it is possible that the South African Government policies, guidelines and strategies that have been employed to increase enrolments of women in general and Black women in particular in science, are finally eradicating the problem of under-representation of Black females in SET, although academic achievement in science still poses a threat to these learners.

Because science attitude and job stereotype scores were moderate it appears that occupational sex-role stereotypes which are enforced by socialization processes (see 3.7.2) which females come across in society, might be diminishing.

5.4 Multivariate analyses

According to the statistical analyses plan (see Appendix C), each dependent variable was analysed using linear regression and analysis of covariance techniques. The confounding and independent variables are put into the model and variables with the least significant relation to the whole are removed one at a time.

5.4.1 Linear regression analyses

Table 10: Table Stepwise model of predictors of biology marks.

Model	Independent variables in the model	Variable removed in the model	F-statistic for variable to be removed	Degrees of freedom	p-value
1	Science A; job S; Age psycho; Ethnic	Job S	0.15	1.35	0.6983
2	Science A; Age; psych; Ethnic	Ethnic	0.32	1.35	0.5758
3	Science A; Age; psycho	Science A	0.70	1.36	0.4086
4	Age; psycho	psycho	0.72	1.37	0.4009
Final	Age		2.17	1.38	0.1494

The results indicate that there is no significant relationship between job stereotypes, ethnicity, science attitudes, psychosocial factors and age, and marks in biology. The p-value is greater than 0.05.

Table 11: Table Stepwise model selection of predictors of physical science marks.

Model	Independent variable in the model	Variable removed from the model	F-statistic for variables to be removed	Degrees of freedom	p-value
1	Science A; job S; Age psycho; Ethnic	Age	0.88	1.24	0.3582
2	Science A; job S; psycho; Ethnic	Job S	2.26	1.24	0.1454
3	Science A; psycho; Ethnic	Science A	1.22	1.26	0.2799
4	Psycho; Ethnic	Psycho	1.50	1.27	0.2307
Final	Ethnic		2.82	1.28	0.1040

The results show that there is no significant relationship between age, job stereotypes, science attitudes, psychosocial factors and ethnicity, and marks in physical science. The p-value is greater than 0.05.

Table 12: Table Stepwise model selection of predictors of mathematics marks

Model	Independent variable in the model	Variable removed from the model	F-statistic for variable to be removed	Degrees of freedom	p-value
1	Science A; job S; Age psycho; Ethnic	Job S	0.52	1.28	0.4761
2	Science A; Age psycho; Ethnic	Science A	1.83	1.29	0.1862
3	Age psycho; Ethnic	Psycho	2.84	1.30	0.1021
4	Age; Ethnic	Ethnic	3.11	1.33	0.0875
Final	Age		9.13	1.13	0.0049★

The tables show that the relationship between the independent variable as well as the confounding variable and the dependent variable is not significant because all values, are greater than 0.05 which is the level of significance. There is therefore no significant relationship between job stereotypes, science attitudes, psychosocial factors and ethnicity, and marks in mathematics. There is, however, a significant relationship between age and marks in mathematics which will be discussed further on.

The following section provides the analyses of covariance of the dependent variable (biology) against the confounding variables (ethnicity, age and psycho-social factors).

5.4.2 Analyses of covariance of the dependent variable, biology, against the confounding variables, ethnicity, age and psycho-social factors.

Table 13(a): Relationship between marks in biology and ethnicity.

Variable	DF	F-Value	p-value
Ethnic	1 , 38	0.22	0.6393

The table shows that there is no significant relationship between marks in biology and ethnicity. The p-value is greater than 0.05.

Table 13(b): Relationship between marks in biology, age, and psychosocial background factors.

Variable	Regression co-efficient	t-value	p-value
Age	-1.13517915	-1.4	0.1690
Psychosocial factors	-0.46839080	-0.35	0.7300

The results show that there is no significant relationship between marks in biology and the confounders, age and psycho-social factors. Both p-values are greater than 0.05.

5.4.3 Analyses of covariance of physical science against ethnicity, age and psychosocial background factors.

Table 14(a): Relationship between marks in physical science and ethnicity.

Variable	DF	Mean square	t-value	p-value
Ethnicity	1 , 28	144.1500000	2.82	0.1040

The table shows that there is no relationship between marks in physical science and ethnicity. The p-value is greater than 0.05.

Table 14(b): Relationship between marks in physical science, age and psychosocial background factors.

Variable	**Regression co-efficient**	**t-value**	**p-value**
Age	-1.25711575	-1.43	0.1620
Psychosocial factors	1.57746479	1.03	0.3122

The table indicates that there is no significant relationship between marks in physical science and the confounding variables age and physical science.

5.4.4 Analyses of covariance of the dependent variable mathematics against the confounding variables, ethnicity, age and Psychosocial Background factors

Table 15(a): Relationship between marks in mathematics and ethnicity.

Variable	**DF**	**F-Value**	**p-value**
Ethnicity	1 , 32	1.24	0.2733

The results in the table show that there is no relationship between mathematics and ethnicity as a unit. The p-value is greater than 0.05.

Table 15(b): Relationship between marks in mathematics, age and psychosocial background factors.

Variable	**Regression co-efficient**	**t-value**	**p-value**
Age	-3.6814815	-3.21	0.0028★
Psychosocial factors	5.08879023	2.44	0.0198★

In the case of marks in biology and physical science, the confounding variables (ethnicity, age and psycho-social factors) did not have a significant effect on the dependent variable. However, regarding the dependent variable (marks in mathematics) both age and psycho-social factors have a significant effect, but ethnicity not. Table 15 (b) shows a negative t-value. Because the t-value is negative it means that the higher the age the lower the marks in mathematics. This indicates that the older the children are, the worse their performance in mathematics is. The reason could be that these learners might have repeated grades or they might have dropped out from school and returned or they might have attended school late as might be the case with students coming from farms. Students coming from farms might have to travel great distances to school and sometimes parents might keep their children at home until they are old enough to be able to travel those distances. This might be the reason why the Department of Education in South Africa has provided transport for these learners, although recently they are being placed in hostels in nearby towns.

A high score in the psychosocial background factors is related to a high score in mathematics. A high score in the psychosocial background factors test indicates negative psychosocial background factors. However, in this study, learners with a negative psychosocial background have done better in mathematics. The reason for this is unknown. It could be a random result.

The author became interested to determine whether there was a significant difference between the science marks of the South Sotho females and that of the Xhosa females. This relationship was then investigated.

The relationship between science marks of South Sotho females and Xhosa females was analysed using a t-test.

Table 16: The t-test for the relationship between science marks of South Sotho and Xhosa females.

Variable: Ethnicity	Science Marks LS MEAN	Standard Error	t-value
S Sotho Xhosa	107.772042 120.555916	3.547670 5.028452	0.0480★

It is interesting to find that ethnicity was not a significant confounder because the P-value was greater than 0.05 (see Table 15 (a)). However, the t-test (Table 16) indicates that the performance of the Xhosa females in science was better than that of the South Sotho females. However, it is not known what causes the difference.

5.5 Summary

The chapter provided a discussion of the quantitative results of the study. Data were analysed using univariate and multivariate analyses. All hypotheses were rejected, but some interesting findings were highlighted. It was found that there was no significant relationship between science attitude and occupational sex-role stereotypes of rural Black females towards the natural sciences. These results were discussed with reference to previous research.

The statistical analyses of results also revealed that older females do not perform well in mathematics. Possible reasons which might account for the poor performance of older children in mathematics were highlighted. Another interesting finding was that the Xhosa females performed better in science than the South Sotho females. The researcher stated that the reasons for these differences were not known. Conclusions, recommendations and limitations to the study will now be discussed in the next chapter.

CHAPTER 6

CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

6.1 Introduction

The study has investigated factors that inhibit Black women from enrolling in SET careers in HE institutions. The fact that Black women are under-represented in SET careers and workplaces in South Africa, necessitated that the researcher explore the reasons for the under-representation, by engaging grade 12 Black females in the study. The rationale for engaging Black grade 12 females is that these learners will potentially further their educational aspirations at HE institutions.

In Chapter 2 a literature study that was undertaken revealed that Black women in South Africa are grossly under-represented in SET.

In Chapter 2 the interest and performance of Black women in SET was also explored. Black women were compared to women of other races worldwide, and to men and women of other races in South Africa.

In Chapter 3 a number of factors that might contribute to the under-representation of Black women in SET were explored. Particular attention was given to science attitudes and occupational sex-role stereotypes.

Chapter 4 provided a discussion of the research design and methodology employed in the study. The statistical analyses plan to measure the science attitudes and occupational sex-role stereotypes of rural Black females towards science studies in HE was provided.

In Chapter 5 research results were presented and discussed.

In this chapter conclusions will be drawn, recommendations provided and limitations of the study indicated.

6.2 Conclusions drawn from the study

6.2.1 Conclusions drawn from the literature study

The findings from the literature review suggest that on a global scale there is a general diminishing of interest among school learners and students in general in the study of science, engineering and technology. This diminishing interest can be observed from the secondary school level through to HE institutions (see 2.2.1). When comparing South Africa with the rest of the world regarding interest and performance in SET, it became evident that the SET sector in the country faces difficulties associated with human resources, as is the case internationally. It was also clear that the standard of mathematics and science teaching is far below than that of other countries (see 2.2.2). Despite the great numbers of Blacks in South Africa, many Black students still do not enrol in significant numbers in the SET fields of study. Many of them still enrol extensively in the Humanities at HE institutions (see 2.2.3).

When comparing the performance of males and females in mathematics and physical science in general in grade 12 between 2000 and 2006 in South Africa, the literature review suggests that the gender gap between males and females in participation and pass rates in these subjects is gradually closing (see 2.2.5). The SET fields of study and careers, however, seem to be still dominated by men in South Africa. Gender disparities are still noticeable because more men than women are found to occupy higher positions in the SET sector (see 2.2.5).

When the language proxy method was used to compare Black male and Black female pass rates by province in 2002 (see 2.2.7), it was found that Black males appear to perform better than Black females in all subjects across provinces in the country. Furthermore, it was found that in historically Black schools Black males appear to perform better in mathematics and science than Black females do, while on the contrary, Black females who attend former model C schools seem to perform better than Black females who attend school at historically Black schools in these subjects. Matriculation results and graduation rates in respect of both undergraduate and doctoral degrees attested that Black females, compared to females of other races in South Africa, are not doing equally well in these subjects at secondary school level and at certain programmes at HE institutions (see 2.2.8).

A number of factors, such as lack of role models, aptitude, self-confidence, attitudes towards science, occupational sex-role stereotypes, psychosocial background factors and many others have been associated with the under-representation of females in general in SET careers and workplaces (see 3.1-3.8). Research results authenticate that attitudes play an important role in occupational choices of adolescents. Children's attitudes towards SET careers are influenced by a variety of factors such as self-efficacy, interest and motivation. Gender stereotyping is found to be an explicit type of attitude towards science related fields according to which women should not choose scientific careers. These attitudes are formed because of experiences and societal beliefs about the expected roles of males and females (see 3.6). Some researchers have argued that very little research has been done regarding the under-representation of Black females in SET careers and workplaces in South Africa (see 2.1).

6.2.2 Conclusions drawn from the statistical analyses of research results

Research results revealed that Black women in this study have less (although not significantly so) negative attitudes towards science and do not hold as many (although not significantly so) stereotypical views of male dominated science occupations as has been proven in other studies (see 3.8). In the researcher's view the South African government policies, guidelines and strategies which are used to create awareness that everybody can participate in the natural sciences are gradually becoming more effective. One can speculate that Black female learners have come to realise that they can also participate in the natural sciences, and as South African citizens, they are also expected to contribute to the scientific knowledge of the country.

It is also important to note that, although the literature review strongly suggests that negative psychosocial factors are related to poor academic achievement, the results in this study have proved otherwise. Reasons for these findings are not known. It could appear that learners with more or less similar psychosocial backgrounds in rural areas seem to be at ease with their background situations, with the result that their background factors do not have any significant or minimal effects on their achievements (see 5.4.4).

Another interesting fact to note was that older learners tend to perform poorly in mathematics when compared to younger learners. The reasons for these results are also not known. In some cases in the rural areas older children have to take care of the other younger children and grandparents, either because the parents have sought jobs in urban areas or parents have died because of HIV and Aids related diseases. These conditions place a lot of stress on these female learners with the result that they might have repeated grades and might have experienced low academic achievement in subjects such as mathematics in particular.

It was also found that there were differences in the academic achievements in science of South Sotho females when compared to the academic achievements in science of Xhosa females. The reasons for these differences in science achievements are not known. However, studies conducted in the USA have shown that there are different participation and achievement rates in SET among females of different ethnic origins. The researcher has not come across studies comparing the participation rates and achievement of Black females of different ethnic groups in science in South Africa.

Most importantly, it was found that even if the research results of the present study suggest that science attitudes might have improved slightly and occupational sex-role stereotypes might have decreased, academic achievement in science is still poor. The reasons for the poor achievement in science might be attributed to a lack of motivation to study science. Debacker and Nelson (2000: 245) view motivation to learn as a crucial factor in science education because motivation is linked to "…cognitive engagement and conceptual change". These researchers indicate that decisions to engage in meaningful learning may be influenced by individual learners' motivation, goals for performing the activity, beliefs about their capabilities, the type of task and how important they perceive the task to be. Taylor and Sweetnam (2000: 34) feel that academic achievement of females in the natural sciences, especially in mathematics and physical science, might also be influenced by the science content which appears to be detached from the females' experiences.

Concerning science stereotypic beliefs, Debacker and Nelson (2000: 253) found in their study conducted in America, that adolescent females' scores were lower than those of adolescent males regarding science stereotypes. These researchers argue that although females contested blunt statements of stereotypical beliefs they may still be affected by cultural stereotypes on a less conscious level. This might be the reason why they do not perform well in mathematics and physical science in particular. The same might be true of the females in the present study.

The fact that only 33 females out of 112 took biology, physical science as well as mathematics as subjects at secondary school level suggests that the other females might lack self-confidence and they might also have low self-efficacy and therefore lack interest in mathematics and mathematics related courses (see 3.7.1). Research indicates that students with low self-efficacy are not intrinsically motivated to study science. These numbers suggest that the grade 12 females in the study are still skeptical of following the SET careers and fields of study in higher education institutions because most of them have rather opted for mathematics literacy and other subjects.

In light of the above discussion a number of recommendations are put forward.

6.3 Recommendations

The statistical analyses in this study necessitated the acceptance of all the null hypotheses. Black females might have slightly better attitudes towards the natural sciences and slightly better occupational sex-role stereotypes. However, the average performance of the Black female learners in biology, physical science and mathematics supplied to this study was poor.

It is recommended that educators, parents, curriculum planners, the government and all stakeholders in the education system, continue to encourage participation of Black females in the natural sciences. Since science attitudes may be in the process of changing positively and occupational stereotypes might have become less, more emphasis should be placed on assisting Black females to perform better in science and mathematics. This task is largely dependent on educators teaching these subjects at the primary level as well as the secondary school level. Halpern et al. (2007: 12-46) encourage educators to:

- *Teach students that academic abilities are expandable and improvable*

Halpern et al. (2007: 12-13) purports that learners can be taught that mathematics and science abilities, like all other abilities, can be developed with regular attempts and learning. These researchers indicate that studies have shown that learners with ability, but who view their cognitive abilities as predetermined and constant, are more likely to encounter greater disappointments and lower performance and eventually reduce their attempts when confronted with difficulties. On the other hand, learners who perceive their abilities as expandable tend to keep trying amidst of the frustrations they might encounter in order to enhance their performance in mathematics and science.

- *Provide prescriptive, informational feedback*

Prescriptive, informational feedback concentrates on strategies, effort and the process of learning. According to Halpern et al. (2007: 15-17), the recommendation exclusively pursues feedback that aims at learners' awareness of their beliefs about why they did or did not achieve on a particular task. This boosts students' beliefs about their capabilities in biology, mathematics and physical science. Educators are encouraged to design classroom settings in which learning, improving and understanding are stressed. Educators can also highlight learners' efforts and strategies when explaining examination marks or assignments scores, but should guard against providing praise on simple tasks because this can undercut learners' motivation.

Debacker and Nelson (2000: 255) argue that by emphasising strategy and effort educators enhance a sense of control in learners' own learning. These researchers indicate that this sense of control is specifically helpful for learners who grapple with their schoolwork and who are at the verge of developing the sense that they are helpless when confronted with academic failure. This sense of control is intensified when learners acquire the habit of observing their own progress of learning and ascribing "…progress to effortful use of effective learning strategies".

- *Create a classroom environment that sparks initial curiosity and fosters long-term interest in mathematics and science*

Educators are encouraged to implant mathematical word problems and science activities in interesting contexts. This helps learners to become aware that science is related to their everyday lives. Reading activities should be implanted into the context of science inquiry, where possible, in order to foster situational relevance and further interest (Halpern et al. 2007: 23-25).

- *Provide spatial skills training*

Research has indicated that spatial abilities which are related to performance in mathematics can be learnt and improved with practice on specific tasks. Educators can teach these skills by encouraging girls, at a very young age, to play with toys that entail spatial knowledge, such as building toys. Older children can be taught to mentally imagine and draw mathematics or other assignments so that they can come to terms with spatially demonstrated information. Educators also have to provide opportunities in spatial skills such as mental rotation of images (Halpern et al. 2007: 27).

- *Help learners to structure appropriate study habits and to develop an identity as a learner*

Wlodkowski (2000: 3-4 of 4) encourages educators to assist learners to find a way of acquiring frequent study habits and make this a daily exercise. In this way learning becomes more habitual and interesting. In addition, learners could be assisted in developing an identity as learners. This researcher believes that identity is a strong motivational force. Learners should indicate to themselves who they are and what is it they require from themselves. This type of motivation can help them do better in their learning programs. Mackenzie (2002: 168) indicates that at HE institutions a 'deep learning approach' is required if students are to succeed in mathematics and science related fields. When students use this approach they become highly motivated and interested in the subject and perceive the subject to be relevant, personally or vocationally. If this is the case, secondary school female learners can also be taught to acquire this skill so that when they reach the HE institutions they are already fully prepared to study at these institutions.

- *Engage students in laboratory work in university chemistry*

Reid and Shah (2007: 173) view laboratory work as the most important element in science education at all levels. It is assumed that experimental work is a fundamental part of any science course which allows learners to do practical work. If females view science as detached from their daily experiences then practical work might enable females to see connections in the natural sciences, in particular chemistry, with the real world. Reid and Shah (2007: 177) also emphasize that the development of the ability to make observations, measurements, predictions, interpretations and to design experiments, depends on practical work. Although these researchers emphasize the need for laboratory work at universities they strongly argue that laboratory work in HE should not be seen in isolation, it must be followed by school laboratory experiences. The implication is that when learners enter HE science studies they might be better prepared to engage with the sciences and eliminate the problems of under-preparedness as reported by some researchers (see 6.3). In this regard the South African government has to make serious commitment to provide laboratory experiences for school learners.

- *Increase parental involvement*

Parental involvement and encouragement is of utmost importance to female students in particular. Parents should ensure that time is set aside to allow girls to study at home. Household chores should be distributed equally among boys and girls. Even if parents themselves are not able to help their children with schoolwork they will be able to provide children with opportunities to study at home. Parents should know their children's educators and discuss the progress of their children and seek advice from educators on how to assist their children to enhance achievement.

- *Implement Teachers Mentorship Programmes (TMP)*

Horacke and Fricke (2004) believe that many educators do not have the ability to identify where learners have a poor foundation, and teaching is done without addressing the basics. These researchers believe that the TMP should be provided to biology, mathematics and physical science educators in disadvantaged schools during school hours by experienced mentor educators. To make significant improvements in the teaching and learning of biology, mathematics and physical science, regular structured extra lessons should be given for a number of years at schools. These remedial lessons should be given up to grade 12 until educators themselves are empowered to address the backlog of learners in general in these subjects. Remedial lessons will minimize problems of under-preparedness in science and mathematics when learners enter the natural sciences programs at HE institutions.

Fortunately the South African Department of Education has introduced a policy on Foundations for Learning, RSA DoE (2008: 1-23), whereby a certain program has to be followed in primary schools to address the backlog in mathematics and the Language of Learning and Teaching (LOLT) up to grade 6 level. The program aims at improving mathematics and LOLT skills in primary schools.

- *Prepare secondary school learners for HE*

Studies have shown that many learners who pass the National Senior Certificate are not yet ready to succeed at HE institutions in biology, mathematics and physical science in South Africa (see 6.3). Addressing the Challenges Facing American Undergraduate Education (2006: 5), suggests that the secondary school curriculum should be structured in such a way that graduation requirements of the HE institutions' standards are met. The American Council on Education, together with other organizations, has embarked on the National Diploma Project, which is a state initiative, to increase the number of secondary school learners who leave secondary school, ready to engage with HE institution mathematics and science programs without a need for remediation. HE institutions are encouraged to work with secondary schools to address transition problems. According to this research, remediation is only useful if it deals with small scale inadequacies. Furthermore remediation is inadequate if it has to address national academic unpreparedness of learners in mathematics and science.

- *Implement measures to improve educator qualifications in biology, physical science and mathematics*

Research has shown that often educators (especially primary school educators) are not adequately trained to teach biology, mathematics and physical science (see 6.3). If this is the case, educators teaching biology, mathematics and science should be encouraged to improve their qualifications in order to master the content knowledge of these subjects. Because the researcher is an educator at a primary school it was observed that educators need a great deal of guidance in implementing programs such as the Foundations for Learning. Regular in-service training should be provided to primary school educators to ensure significant improvements in the learners' grasp and mastering of mathematics and LOLT. In addition bursaries should be awarded to all educators who have not been adequately trained to teach these subjects, with special emphasis on primary school educators. In the researcher's opinion the programmes and policies which are aimed at improving the teaching and learning of biology, mathematics and physical science will not be implemented with maximum success if educators themselves lack the content knowledge of these subjects.

In conclusion, recommendations are also provided that are based on the findings of the present research results. While acknowledging initiatives that the democratic government of South Africa has put forward to promote access of women in general to SET careers of study and workplaces, it became evident from the results that some significant gains might have been produced in minimising occupational sex-role stereotypes in Black female learners with regard to male dominated scientific careers. It can de deduced that a decrease in stereotypes resulted in these Black females' science attitude changing positively, although their performance in science is not good. Therefore the government should embark on strategies that could help these learners to achieve in science and mathematics classrooms. Because educators spend much time with students it is hoped that they will also change their attitudes toward females in science (see 3.7) and strive to help these females to find a place in the scientific arena by ensuring that they perform optimally. All stakeholders should reinforce their efforts in helping Black females to achieve in mathematics and science to enable them to claim their rights as other women of different races in South Africa and globally do, because "… lack of achievement in mathematics at school can be a barrier to entry into HE" (Mackenzie 2002: 168).

6.4 Limitations

The sample under study was relatively small (n=112) and out of the 112 participants only 33 took all three subjects namely biology, physical science and mathematics as subjects at grade 12 level. Only Black female learners from 5 schools in the Xhariep district, in the Southern Free State took part in the study. Sampling was done based on proximity of the schools. This study was limited because it did not explore and compare the science attitudes and the occupational sex-role stereotypes of Black females to that of Black males. Because random sampling was not done, these results cannot be generalised to the Southern Free State rural Black females, but they can possibly be used to affect the mindsets of educators and curriculum planners to view Black females as also being interested in science but possibly being discouraged to follow SET studies and careers because of poor performance in school mathematics and science.

Using self-report inventories, as was the case in this study, set an arguable limitation to the study. In such inventories participants might only give censored or biased information. In practice however this rarely happens since the Alpha Cronbach of the measuring instruments was high.

6.5 Further research

The literature study undertaken showed that little research has been conducted on factors inhibiting Black females from following careers in SET (See 2.1), it is suggested that further research be undertaken to:

- Explore the attitudes and occupational sex-role stereotypes of Black females in rural areas towards natural science studies in HE with much larger samples.
- Compare the attitudes and occupational sex-role stereotypes of both Black rural male and female students towards natural science studies in HE with a much larger sample.

6.6 Conclusion

The significance of the research is that the science attitude and occupational sex-role stereotypes of rural Black females were investigated and analysed. By this means information regarding the problem of under-representation of females' entrance into natural science studies in HE was investigated. The research results could shed light on the possible reasons why females do not enrol in great numbers in science and mathematics at secondary school level as well as in the SET fields of study at HE institutions. Such knowledge could ultimately pave the way for measures by means of which the problems could be appropriately addressed. Possible hypotheses for further study can be formulated from the study thus promoting more research in this area.

Furthermore, the rationale for embarking onto such a challenging study has personal significance. The personal significance of the study is that, the researcher's own position as a primary school natural science and technology educator in the rural areas of the Xhariep district has put the researcher in an excellent position to undertake the study, understand the situation and strive for improving female performance in the natural sciences and technology as subjects at primary school level. Studies have shown that science attitudes and sex-role stereotypes are formed as early as primary school (see 3.7.1).

It is hoped that these recommendations will be used by the government, education officials and the parents in order to help Black females to achieve in science at secondary school level. It is also hoped that, these efforts might increase the participation of Black females in the natural sciences, and particularly in the SET fields of study, at HE institutions and in workplaces. The Department of Science and Technology (RSA DST 1998: 44) emphasizes that

"… Scientific achievement builds national pride. A nation without a core of scientific competence will in the end be held to ransom by foreigners. Because scientific research fulfills a fundamental need, a nation will loose gifted people and their contributions when science is neglected. Neglecting science is in the end the recipe for mental and material poverty".

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APPENDIX: A

QUESTIONNAIRE

THE ATTITUDES AND OCCUPATIONAL SEX-ROLE STEREOTYPES RELATING TO NATURAL SCIENCE STUDIES

INSTRUCTIONS
Read the questions carefully.
Please indicate your response by making an 'X' at the appropriate block.

SECTION A: BIOGRAPHIC INFORMATION

1-13

Student number													

2. Age of respondent

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14

Age	

3. Language

15

Language	
South Sotho	1
Xhosa	2
Tswana	3
Other	4

4. Marks

16

Marks in Biology	June 2008	November 2008	Total Average

5. Marks

17

Marks in Physical Science	June 2008	November 2008	Total Average

6. Marks

18

Marks in Mathematics	June 2008	November 2008	Total Average

SECTION B: SCIENCE ATTITUDE SCALE FOR MIDLLE SCHOOL STUDENTS

This questionnaire is going to measure your attitude towards science. The scale ranges from 'Completely disagree' to 'Completely agree'. Please indicate with an 'X' in the box of your choice.

7. Getting science books from the library is boring

1	2	3	4	5	6	19
Completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree	

8. I hate to keep records of science experiments in a note book.

1	2	3	4	5	6	20
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree	

9. Science films bore me to death.

1	2	3	4	5	6	21
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree	

10. I wish science classes lasted all day.

1	2	3	4	5	6	22
completely disagree	moderately disagree	disgree	agree	moderately agree	completely agree	

11. I dislike watching science specials on television.

1	2	3	4	5	6	23
completely disagree	moderately disagree	disgree	agree	moderately agree	completely agree	

12. I hate science classes. 24

1	2	3	4	5	6
completely disagree	moderately disagree	disagree	agree	moderately agree	Completely agree

13. Learning science facts is boring. 25

1	2	3	4	5	6
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree

14. Working with science equipment makes me feel important. 26

1	2	3	4	5	6
completely disagree	moderately agree	disagree	agree	moderately agree	completely agree

15. I would like to join a science club that meets after school. 27

1	2	3	4	5	6
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree

16. Looking through a microscope is not my idea of fun. 28

1	2	3	4	5	6
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree

17. Knowing science facts makes me feel good. 29

1	2	3	4	5	6
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree

18. I don't mind doing an experiment several times to check the answer.

30

1	2	3	4	5	6
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree

19. I feel like daydreaming during science class.

31

1	2	3	4	5	6
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree

20. Sharing science facts that I know makes me feel great.

32

1	2	3	4	5	6
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree

21. I hate to study science out of doors.

33

1	2	3	4	5	6
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree

22. It's fun to talk to my parents about science.

34

1	2	3	4	5	6
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree

23. I like to make science drawings.

35

1	2	3	4	5	6
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree

24. I wouldn't think of discussing science with friends outside class.

1	2	3	4	5	6	36
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree	

25. I enjoy using mathematics in science experiments.

1	2	3	4	5	6	37
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree	

26. I cannot wait until science class.

1	2	3	4	5	6	38
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree	

27. I wish we didn't have science classes so often.

1	2	3	4	5	6	39
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree	

28. Doing science projects at home is stupid?

1	2	3	4	5	6	40
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree	

29. Science is one of my favourite classes.

1	2	3	4	5	6	41
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree	

SECTION C: JOB STEREOTYPING

Please indicate how you feel about traditionally male professions. Indicate your feelings with an X in the block of your choice.

30. It is acceptable for a woman to be a paint technician. (someone who uses knowledge of the physical sciences like chemistry, physics and mathematics to address complicated industrial problems concerning paint and its use)

1	2	3	4	5	6	**42**
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree	

31. It is acceptable for a woman to be an electrical engineer. (someone who is involved in research projects, complicated designing in the manufacturing field, the testing of equipment or the testing of installed machines)

1	2	3	4	5	6	**43**
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree	

32. It is acceptable for a woman to be a wood technologist. (someone who uses many different processes to convert a tree into products that can be sold in the form of sawn timber, plywood, particleboard or treated poles)

1	2	3	4	5	6	**44**
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree	

33. It is acceptable for a woman to be a metallurgical engineer. (someone who is trained in processes and methods for turning waste into something useful and processing of ore and mineral resources, as well as the study of metals and alloys)

1	2	3	4	5	6	**45**
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree	

34. It is acceptable for a woman to be a radiation protectionist. (someone who is involved in the protection of humans and the environment against the dangerous effects of the incorrect use of radiation and radioactive materials)

46

1	2	3	4	5	6
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree

35. It is acceptable for a woman to be an agricultural engineer. (someone who applies the engineering principles of science and technology, as well knowledge of agricultural practices to agricultural problems)

47

1	2	3	4	5	6
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree

36. It is acceptable for a woman to be an explosives technologist. (someone who is involved in the manufacturing of commercial (trade) and military (war) explosives as well as its evaluation and application)

48

1	2	3	4	5	6
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree

37. It is acceptable for a woman to be a nuclear scientist. (someone who develops knowledge, techniques, equipment or products related to modern nuclear physics and nuclear chemistry and applies these for solving science-related problems in areas such as medicine, industry, agriculture and mining)

49

1	2	3	4	5	6
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree

38. It is acceptable for woman to be a mine surveyor. (someone who undertakes both underground and surface surveys designed to produce information for the construction of mine plans)

50

1	2	3	4	5	6
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree

39. It is acceptable for a woman to be a statistician. (someone who gives meaning to numbers and includes all the ways in which information is collected , processed and interpreted)

51

1	2	3	4	5	6
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree

40. It is acceptable for a woman to be a land surveyor. (someone who is involved in the science of recording and setting out the exact measurements of man-made and natural features of the earth's surface. It also involves the making of maps and the determination of boundaries)

52

1	2	3	4	5	6
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree

41. It is acceptable for a woman to be a chemical engineer. (someone who uses knowledge of chemistry, physics and chemical engineering to design and operate processes for the large scale production of chemicals, plastics, minerals and other useful commodities)

53

1	2	3	4	5	6
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree

42. It is acceptable for a woman to be a biomedical engineer. (someone who designs and develops medical instruments and devices such as cardiac valves, surgical implants and mobility aids for the handicapped)

54

1	2	3	4	5	6
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree

43. It is acceptable for a woman to be an industrial engineer. (someone who uses knowledge and skills from mathematics, statistics, economics, physical and social sciences to design better methods and facilities for manufacturing and services)

55

1	2	3	4	5	6
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree

44. It is acceptable for a woman to be an automotive electrician. (someone who manufactures, installs and repairs electrical systems and equipment for motor vehicles)

56

1	2	3	4	5	6
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree

45. It is acceptable for a woman to be an astronomer. (astronomy involves the study of stars, comets, planets as well a collection of stars such as globular clusters (up to 1 million stars) and galaxies (up to 100 million stars), it is also concerned with how and when the universe began and what will happen to it in future)

57

1	2	3	4	5	6
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree

46. It is acceptable for woman to be an aquatic scientist. (someone who studies physical, chemical, biological and ecological aspects of inland and marine water environments)

58

1	2	3	4	5	6
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree

47. It is acceptable for a woman to be a civil engineer. (someone who is involved in the constant recreation, improvement and conservation of the environment as well as the establishment of facilities such as buildings, roads, bridges, airports and dams that are required for the effective functioning of a community)

59

1	2	3	4	5	6
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree

48. It is acceptable for woman to be a farmer. (someone responsible for the production and marketing of a country's food and fibre either through crop- and stock farming)

60

1	2	3	4	5	6
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree

49. It is acceptable for a woman to a mechanical engineer. (someone who develops, implements, manufactures and maintains machines, machine components and systems in various fields to enhance the quality of life)

61

1	2	3	4	5	6
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree

50. It is acceptable for a woman to be a physiotherapist. (someone who uses hands, mechanical and electrical machines as well as natural elements such as heat and cold to help people with the physical treatment of injury and disease)

62

1	2	3	4	5	6
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree

51. It is acceptable for a woman to be an architect. (someone who designs, plans and decorates houses and large buildings)

63

1	2	3	4	5	6
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree

52. It is acceptable for a woman to be an aircraft mechanic. (someone who is taught the skills and procedures necessary to diagnose, correct and maintain aircraft structures and their related components and the embodiment of approved alterations)

64

1	2	3	4	5	6
completely disagree	moderately disagree	disagree	agree	moderately agree	completely agree

SECTION D: PSCHOSOCIAL BACKGROUND OF STUDENTS

This instrument was designed to determine in what kind of environment you were raised. And what the situation is regarding your present situation. Please read the questions carefully and answer as truthfully as you can. Rate the given aspects of your life by marking the block that is closest to the description of that aspect.

EXAMPLE:

Going to school was: **65**

Interesting and enjoyable	1	2	3	4	5	6	Uninteresting and boring

CHILDHOOD YEARS

EMOTIONAL SUPPORT

53. While growing up I experienced **66**

Love and support	1	2	3	4	5	6	Abuse and neglect

54. I grew up being: **67**

Part of a family	1	2	3	4	5	6	Missing family love

55. The people in my family were: **68**

Caring towards each other	1	2	3	4	5	6	Often fighting/arguing

Socio economic situation

56. Regarding money we are: **69**

Comfortable	1	2	3	4	5	6	In distress	

57. The house we live in is: **70**

Big enough	1	2	3	4	5	6	Crowded	

58. The neighbourhood we live in is: **71**

Respectable	1	2	3	4	5	6	Not well regarded	

ENVIRONMENT CONDUCIVE TO LEARNING

59. The occupation of one or both of my parents or guardian filled me with: **72**

Admiration	1	2	3	4	5	6	Disapproval	

60. In my family the opportunity to learn something new is regarded as: **73**

Important	1	2	3	4	5	6	Not important	

61. My parents/guardian made sure that I have the opportunity to experience books, magazines, dictionaries, TV and videos. **74**

Often	1	2	3	4	5	6	Never	

62. Regarding further education, my parents/guardian: **75**

Have high expectations	1	2	3	4	5	6	Are not concerned about my future	

DEPRESSION

63. When I was growing up I felt depressed or down: **76**

Seldom	1	2	3	4	5	6	Often	

64. As a teenager I think that life is not worth living:

Seldom	1	2	3	4	5	6	Often	77

65. Depression or aggression/ drinking is experienced by one or more of my blood relatives:

Seldom	1	2	3	4	5	6	Often	78

66. I would rate my childhood as:

Happy	1	2	3	4	5	6	Unhappy	79

THANK YOU FOR YOUR TIME IN COMPLETING THIS QUESTIONNAIRE

APPENDIX B:

CONSENT FORM

Attitudes and occupational sex-role stereotypes relating to natural science studies in higher education among rural black females.

Declaration by or on behalf of the Participant:

Respondent number													

A I, the undersigned confirm that:

1. I have been asked to participate in the above mentioned research survey carried out by the University of Free State (UFS)

2. It has been explained to me that:

2.1 The purpose of the research survey is to collect information on the attitudes and occupational sex-role stereotyping of black females towards science studies in higher education as well as information regarding their general background. The information collected will be used to determine which factors influence learners' career choice.

2.2 In order to collect this information I have been told that I will be asked a number of questions regarding:

- Biographical details;
- My background;
- My feelings and thoughts about different occupations.
- My feelings and thoughts about science.

2.3 I have been told that this information will be collected from grade 12 learners in this and other schools and I will be asked these questions once.

2.4 I have been told that it will not take more than 60 minutes to collect the information.

3. It was also explained to me that by participating in this research survey I will help students in Xhariep District to make better decisions about their careers.

4. It was also explained to me that the information will be kept confidential but that it will be used anonymously for making known the findings to other educationists.

5. I understand that I will not have direct access to the results of the survey but I can contact the researcher who will inform me of the findings.

6. It was also clearly explained to me that I can refuse to participate in this research survey. If I refuse, it will not be held against me in any way.

7. The information in this consent form was explained to me by Mrs Makate in English, Sotho and Xhosa and I confirm that I have a good

command of one of these languages and understood the explanations. I will also be given the opportunity to ask questions on things I do not understand clearly.

8. No pressure is applied to me to take part in this research survey.

B I hereby agree voluntarily to take part in this research survey.

Signed/confirmed at.......................................On...

....

Signature or hand mark of Participant   Signature or hand mark of witness

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Signed/confirmed
at......................................On..

....
....
Signature or hand mark of Participant

Signature or hand mark of witness

APPENDIX C
ATTITUDES AND OCCUPATIONAL SEX-ROLE STEREOTYPES RELATING TO NATURAL SCIENCE STUDIES IN HIGHER EDUCATION AMONG RURAL BLACK FEMALES

Statistical Analysis Plan

Objective of statistical analysis

The primary objective of statistical analysis is to investigate the effect of science attitude and job stereotyping on science marks, while adjusting for the following potential confounders: age, ethnicity and psychosocial background factors.

Descriptive analysis

Frequency tabulations (number of students and percent of learners per category) for the following will be presented:

- Ethnicity

***Software**: SAS Proc FREQ.*

Descriptive statistics (mean, SD, median, mean, max, number of observations) will be presented for each quantitative variable, namely

- o Score on Science attitude scale for middle school children
- o Score on Job stereotypes
- o Marks in biology
- o Marks in physical science
- o Marks in mathematics
- o Age
- o Psychosocial background score

***Software:** SAS Proc MEANS*

Univariate analysis

The three dependent variables are the following:

- o Marks in biology
- o Marks in physical science
- o Marks in mathematics

Each dependent variable will be analysed using one-way ANOVA fitting the categorical confounding variable:

- Ethnicity

Each dependent variable will be analysed using simple linear regression fitting (one at a time) of the following variables:

- o Score on Science attitude scale for middle school children
- o Score on Job stereotyping
- o Age (continuous)
- o Psycho-social background score (continuous)

Software: *SAS Proc GLM*

Multivariate analysis

Each independent variable will be analysed using linear regression and analysis of covariance techniques. Initially, the analysis of a covariance model for each dependent variable will contain the two independent variables (score on Science attitude scale for middle school children and score on Job stereotyping) and all potential confounders (age, ethnicity and psychosocial background score) F-statistics and associated P-values will be calculated for each variable in the model. Stepwise model selection will be applied by removing, one at a time, that variable among the confounders which is least significantly associated with the outcome, providing that the P- value is at least 0.1.***Software:*** *SAS Proc GLM*.

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Signed/confirmed at.......................................On...

....

Signature or hand mark of Participant

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- Score on Science attitude scale for middle school children
- Score on Job stereotypes
- Marks in biology
- Marks in physical science
- Marks in mathematics
- Age
- Psychosocial background score

Software: *SAS Proc MEANS*

Univariate analysis

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- o Score on Job stereotyping
- o Age (continuous)
- o Psycho-social background score (continuous)

Software: *SAS Proc GLM*

Multivariate analysis

Each independent variable will be analysed using linear regression and analysis of covariance techniques. Initially, the analysis of a covariance model for each dependent variable will contain the two independent variables (score on Science attitude scale for middle school children and score on Job stereotyping) and all potential confounders (age, ethnicity and psychosocial background score) F-statistics and associated P-values will be calculated for each variable in the model. Stepwise model selection will be applied by removing, one at a time, that variable among the confounders which is least significantly associated with the outcome, providing that the P- value is at least 0.1.***Software:*** *SAS Proc GLM*.