GENDER AND PERCEPTIONS OF SCIENCE AND SCIENCE EDUCATION: A CASE STUDY IN MITCHELLS PLAIN

DISSERTATION SUBMITTED FOR THE DEGREE DOCTOR OF PHILOSOPHY IN THE ARTS, WOMEN'S AND GENDER STUDIES, UNIVERSITY OF THE WESTERN CAPE

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ABSTRACT

The literature on the manner in which gender influences the participation and performance of girls and boys in science and science education indicates that the disparity between the genders, in favour of boys, persists. This has negatively affected the participation rates of women in tertiary science education and the science workplace. Gender inequality, an outcome of socio-cultural relations, is regarded as being at the root of this disparity. Science is regarded as a male domain; a feminist analysis has viewed the position of women in science as emanating from a history of the oppression of women in male-dominated society. Through socialisation and cultural practices, society encourages the development of binaristic, gendered norms and roles: a fertile environment for the perpetuation of the gender role stereotypes portraying boys as more science-orientated than girls.

Schools are regarded as prime sites for the perpetuation of gender inequalities. The socio-cultural perceptions that educators and learners alike bring into science classrooms influence their thinking about gender in science and science education. The interactive social milieu of the classroom is viewed as the crucible where attitudes to, beliefs in and perceptions of the role of gender in science are shaped.

In addition, the media functions as a socio-cultural agent, both in its popular form and as a source of resource material for science teaching. The masculine image of science and scientists it persistently promotes influences girls' and boys' attitudes to, beliefs in and perceptions of science and science education.

The study examines gender and the perceptions of science and science education of boy and girl learners in the General Education and Training (GET) phase of education i.e. Grades 7 to 9. The research methodology comprised both quantitative and qualitative methods. The quantitative study entailed conducting a survey of six hundred Grades 7, 8 and 9 boy and girl learners in an English medium school. A small sample of 26 learners was randomly selected from each of the Grades 7, 8 and 9 for semi-structured, in-depth, individual interviews. Age, grade and gender were the selection criteria. All participant schools are situated in an educational district in Mitchells Plain, Cape Town, South Africa: the majority of residents in the suburb are from the lower middle class and were classified Coloured according to the Apartheid racial classification. The educators administering the qualitative, semi-structured, in-depth interviews were also drawn from this group.

The findings confirmed that gender role stereotypes persist in science and science education. Girls are drawn to affective science pursuits whereas boys are firmly rooted to stereotypical perceptions of the masculine image of science and science careers. It is apparent that girls are

challenging sex-role stereotypes in science and agitating for gender equity in science education and science careers.

Key words: gender, equity, science, education, stereotypes, perceptions.

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DISCLAIMER

I, Mogamad Waheeb Gasant, hereby declare that the work contained in this dissertation is my own, original and unaided work that has not been submitted to any other institution before for assessment purposes and that all sources, references and peer, tutor and other assistance have been acknowledged.

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Mogamad Waheeb Gasant

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CHAPTER ONE
The content, context and rationale of the study

1.1 Introduction

The scope of this thesis centers on the cohort of learners that are in grades seven to nine. It looks at the manner in which gender mediates their perceptions of science and aspects of its teaching and how these perceptions are articulated in their social and academic lives: in their homes, their interaction with others and in the school environment. The point of interest is the manner in which gender influences learners' activities and social interaction that centres on science and science education and whether there are gender differences in these perceptions. The thesis tries to uncover what influences these perceptions and to this end it looks at aspects of learners' lives that are connected to science and science education. The manner in which gender stereotypes are perpetuated in society through communication networks like the print and electronic media and other forms of social interaction in specific environments like science classrooms are investigated for their potential to influence learners thinking and actions around science. Data on the learner perceptions of science and science teaching was achieved by qualitative as well as quantitative means and the extent of the influence of gender on these perceptions was ascertained in the interpretations gleaned from the analysis of the data. Nuances in social interaction were used as a means of establishing the foundations of learner discourse on gender and its influence on their perceptions of science. The thesis drew conclusions on the role that gender has on learner perceptions of science and recommendations were made about measures to manage societal influences that impact these perceptions.

This chapter will state the problem that has been identified with regard to gender and science, particularly the reasons for the masculine image that science has acquired, and provide a background to the challenges that we face in this field in South Africa. It will trace the origins of the need for the research and sketch in broad terms the problem of the manner in which gender roles have become stereotyped, particularly in science, because of perceptions of the way in which girls and boys should behave, what they should interest themselves in and what careers they should pursue. The chapter deals with how women have empowered themselves to counter these perceptions and have spread this message to argue against the gender bias that exists in science, science education and science careers. The chapter also focuses on how this problem manifests in South African society, its educational institutions and its workplaces and delves into one of the roots of the problem, the learners' selection, or not, of Physical Sciences in the Further Education and Training (FET) phase of education in South Africa. It provides a South African setting for the lack of participation of girls in science and locates the problem by contextualising the local Western Cape

background of the study (see Figures 1.1, 4.1 and 4.2). My personal motivation for embarking on the study is also provided.

The chapter then explains the rationale for this study by contextualising the discrepancies in the participation and performance rates of South African girls in science and science education and the subsequent participation of women in science careers. These discrepancies take place against the backdrop of a developing country emerging from the social upheaval caused by Apartheid and its continued impact on the research topic. The chapter concludes with an overview of the chapters in the thesis to give the reader a guide to how it responds to aspects and nuances of the problem.

1.2 The statement of the problem

As principal of a secondary school participating in the Dinaledi Project, a South African national Physical Sciences and Mathematics improvement strategy, the constant lament of the lack of girls entering the engineering science faculties at tertiary academic institutions and the concomitant shortage of specifically women scientists in South Africa, inspired me to embark on an investigation of this apparently worldwide problem. The discrepancy in the participation rates of women, as compared to men, in science is linked to learners' perceptions of science and science education as a masculine pursuit. Sandra Harding (2006, p.70) has the following to say about the issue:

> "Today, when the formal barriers against women's access to science and engineering education, degrees, publication, lab appointments, and membership in scientific societies are finally illegal in Europe, the United States, and many other parts of the world, it remains challenging to identify and then eliminate powerful continuing sources of discrimination."

Harding's (2006) argument provides me with the setting for unpacking the problem of the masculine image that science has acquired and that persists, such that science continues to be regarded as a male domain, effectively sidelining women in its activities, its careers and its epistemology. Perceptions of gender and how these perceptions prescribe what men and women are expected to do, and in some cultures curtailed from doing, in society, are at the root of this image of science.

Gender differences and the way in which they play out in the social, cultural and economic spheres of community life are constantly being highlighted in research, social interaction and in the media, giving credence to the fact that ongoing discriminatory practices based on gender have their origin in the fundamentally different perceptions that men and women, girls and boys hold of gender and its meaning in society. These differing perceptions have their origins in the constructs that we have built up around gender, like girls and boys dressing differently, and the distinct manner in which these are infused in the norms and values of diverse cultural and religious groupings in our society.

This phenomenon is not peculiar to a specific country or community and indeed, differing perceptions of gender and the discriminatory practices that they spawn, are a worldwide, cross-cultural phenomenon that spans diverse socio-cultural communities. These perceptions result in different behaviour patterns and social practices towards different genders and are produced and reproduced such that they become embedded in stereotypes. Since they have historically been perceived as male domains, science and science education have become terrains where gender differences and the manner in which they play out have been contested. Within the South African context of diverse and unequal social circumstances, the worldwide gender issue in science becomes accentuated and its effects compounded. In South Africa, access to science, science education and science careers is interceded by culture, race, class, poverty and ethnicity.

Within the framework of technological development, industrialisation and the modernisation of economies, concomitant social changes have served as a backdrop to the push for equal rights. This has created fertile ground for the questioning of gender stereotypes and long-held perceptions of the role of women in society. Women's rights and gender power relations are at the centre of women's struggle for equal opportunity in the science workplace: besides the implications brought on by their gender, the social conditions that girls have to contend with, especially where they are subject to racial, ethnic and class discrimination, mediates the way in which they experience their schooling and compounds the effects that gender inequalities have on their opportunities and the way that they are perceived in society. Not only does the social context of girls' lives impact on their life opportunities but, in addition, the way in which girls experience being girls and how they construct their feminine identities, play a part in girls' identity development in the context of gender power relations, the promotion of women's rights, as well as their experiences in science classrooms. In themselves, poverty, ethnicity, race and class limit access to education but in the case of girls, these intersect in complex ways with gender, and lead to their further disadvantage. Catsambis (1995, p.25) notes that:

> "Race and ethnic differences, and possibly socioeconomic differences associated with minority status, are as strong as gender differences in science, and warrant further exploration."

This issue is of particular relevance in South Africa, a country emerging from a formalised, racially divided socio-political system to one that is purported to be focused on equal opportunity, regardless of race and class. The effect of this job reservation system, of entrenching racial division in the conduct of the labour relationship on the labour market is described by Sonia Bendix (2000, p.87):

> "...introduced a system of job reservation whereby a particular occupation could be legally reserved for a certain race group. Contrary to common belief, jobs were not necessarily reserved for Whites, but for members of a single race group."

Many of the legal measures of the Apartheid system as it related to careers were legally abolished only in 1994. Whilst affirmative action policies in the private, commercial as well as public, formal sectors are in place, the effects of Apartheid on the labour market are still evident and are set to continue a while longer. The Apartheid ideology decreed that 'non-Whites' were not fit for certain jobs. It was hierarchical in its application of the classification of jobs such that there would be a 'pecking order' of jobs, filled firstly by White[1] males, then White females, then Indian and Coloured males, Indian and Coloured females, Black males and lastly Black females. Sonia Bendix (2000, p.416) sums up the employment situation thus:

> "...the employment situation ... is largely a result of the dichotomy in the labour field prior to 1979 and of the still existent inequality between the different race groups as regards both economic circumstances and educational opportunity, which are important criteria in determining employability."

The lingering after-effects of Apartheid still impact previously disadvantaged girls' lives as they aspire for equal treatment and opportunity. The context of learners' lives is permeated by social constructs like gender, race and class and this influences the way in which they 'experience' and benefit from education. South Africa has nevertheless made significant progress with regard to access for girls to primary and secondary education, as reflected in the *OECD (Organization for Economic Co-operation and Development) Report on South Africa* (2008, p.51), for example:

> "Contrary to the situation in many developing countries, the data for South Africa show that about the same number of girls attend schools as do boys and that gender parity has been reached."

Nonetheless, there are still challenges with regard to perceptions of and attitudes to science in that the number of girl learners accessing science in the FET band is lower than the number of boys (see Figure 1.2), and the numbers of women in engineering still lags far behind the number of men. The label of science as a masculine pursuit persists.

1.2.1 The masculine image of science

[1] The use of capital letters when using racial descriptors is contentious, particularly in South Africa. For purposes of consistency, all descriptors of race have been capitalised in accordance with the usage of these terms by the South African Department of Labour and not to denote the supposed superiority of any one group.

Notwithstanding the view that science is socially neutral, it constantly needs to answer to criticisms of 'bad science' when some of the byproducts of its endeavours are used in a manner that has negative outcomes in society. When the "human context of science" and the "relation between science and human values" (Halsey and Friedman, 1984, p.498A) are investigated, science would appear to be lacking in its supposed value-free nature. Science's development of instruments of war such as nuclear power and the negative social side-effects of the development of technology like the Internet are cases in point. This strengthens reservations that some have about the purportedly noble nature of science, the identity that it has developed and its goals. Despite mainly Western views about science's social neutrality, Harding (2006, p.4) remarks that:

> "Yet critics point out that themes of male supremacy, racism, class exploitation, and colonial and imperial exploitation and domination, transformed from era to era and place to place, still persist throughout much of this social variation and change…"

Whilst there certainly were women pioneers in science, science as an activity based on power over matter developed in the pre-industrial era (Halsey and Friedman, 1984) was pursued and promoted by males for a male-dominated society. It developed in the environment of the reproductive, caring and nurturing role that had been assigned to women by those (generally men) who held political and economic power and wielded this power in the social sphere. The need for the invention of technologies for waging war served as a strong motivation for many of the developments in science. Warfare is perceived still today as a male pursuit, as evidenced by the overwhelming numbers of male as compared to female soldiers. (The uniformed services of the South African National Defence Force mustered 64 431 personnel in April this year, of whom 77.3% (49 831) were male: http://www.defenceweb.co.za, 2011). Currently, even where women are deployed in war, it is mostly in roles supportive of men. The origin and development of science as a discipline is rooted in hegemonic versions of masculinity (Connell, 2007) and it has an image that appears to be difficult to shake. As a result, it becomes challenging for women to find their space in science and to be regarded as equals in the discipline.

Social structures become the vehicles through which gender-stereotypical perceptions are propagated. Images in the popular media and practices in education systems appear to be supportive of this male image and reproduce it for younger generations to perpetuate. The media has become a powerful social agent in the production and reproduction of the masculine image of science. Their role has grown in importance, since we are in an age where modern technologies like television, computers and cellular phones are the trappings of the young and are tools for accessing and influencing perceptions, especially of science.

The schooling system, with its dual role of promoting social stability whilst encouraging social change to meet the demands of a changing world, is one of the more significant settings in which the masculine image of science is reproduced and where, importantly, it needs to be countered. The challenge lies in the fact that education has to promote equal human rights, including facilitating women's and men's equal access to science and science education. The education system is however, failing in this goal, at least in the South African context, and is regarded as a significant arena for perpetuating the masculine image of science.

1.2.2 Gender equality and women's empowerment

The drive for gender equality and the empowerment of women, and feminist movements more broadly, exposed the effects that gender imbalances have on society in sidelining women and denying them equal rights in all fields and especially in the science field. The importance of feminist theory and activism raising the 'women in science' debate cannot be overemphasised. Whilst improved women's access to economic and political rights is a natural outcome of the success of gender equity policies, women's actual involvement in science education, economics and politics, however, is bogged down by systemic, structural realities, as well as by ideologies that do not necessarily make it easy for them to engage. For example, in a study of Asian countries that are "Newly Industrialised", "in transition to market economies" or "Least Developed", Jayaweera (1997, pp.422-423) has found that, whilst access to education has improved, education itself

> "has not been able to counter the economic and social constraints that perpetuate poverty and social class differentiation or the social construction of gender that reinforces gender inequality in the family, labour market and society."

It would appear that developing countries, of which South Africa is recognised as one, with economies that are emerging and not as industrialised as those of First World countries, find it more challenging to achieve gender equality. In these countries the gender imbalance appears to be embedded more firmly in socio-cultural norms and values which impact on the division of labour more acutely, in that it is quite 'normal' in societies for women not to be involved in certain types of activities. The outcome of gender equity policies – women's increased workplace mobility as a consequence of improved access to education – is thus stifled when only limited inroads have been made in dismantling the gendered division of labour. The gendered division of labour in the science field is further complicated by the fact that South Africa, as a developing state, is regarded as having an economy that comprises First World as well as Third World features.

Evans (1996) makes the observation that societal processes are at work to maintain the status quo and to reproduce the structures of society. In putting the 'gender in science' debate in

perspective, some researchers suggest viewing women as minorities and ascribing to them the status and rights which should be afforded to minorities. In relation to the debate on the role of girls in science education, feminist works express the view that schools are key sites where inequality between the sexes is produced and reproduced (Clair, 1995). Schooling is understood as one of the societal processes which reproduces society's values and is the environment in which adults form a 'living curriculum' (Parker, Rennie and Fraser, 1996) from which learners get their lessons. Schools are thus seen as a significant part of the societal context in which girls' and boys' perceptions of their roles and place in science education are differently constructed. Kreinberg and Lewis (1996) allude to this 'living curriculum' when they maintain that the influence of the perspectives, values and background experiences of the dominant (male) culture is reflected in science education as that of a 'hidden curriculum'.

The struggle for women's empowerment in the gender disparity debate, as embodied in the rhetoric and actions of feminist movements, has impacted positively in bringing about a move towards gender equity and has, at the very least, created awareness in communities about the issues. However, it is evident that there is still a long way to go.

1.2.3 The challenges of science and gender: the South African context

The problem of the masculine image that science has fostered is reflected in the education system in South African and in its workplaces. This problem is complicated by the challenges of the unique history, culture and socio-economic context of the country. For example, as a post-Apartheid, developmental state, South Africa's economy has Third World as well as First World social issues that need attention. This, coupled with the fact that the country's population is culturally and racially diverse and at different class levels socially and economically, presents a challenging environment for the promotion of gender equality. Socio-cultural behaviour patterns that reflect perceptions of gender are different and sometimes conflicting in groups that are situated differently in society. Gains have been made, however, as evidenced in an article in *The Times* (Thursday 14 October, 2010): it reported that in a recent survey, South Africa was placed 12th amongst 134 countries in the Global Gender Gap Index due to "its high numbers of women in Parliament and ministerial positions and narrow education gaps". This indicates that the country is making significant strides in reducing gender inequality in certain sectors.

However, a look at equality of opportunity, as incorporated in the structuralist approach to gender, provides a different picture of South Africa: that of unequal representation of women as compared to men in areas where power, decision-making authority and control over resources play a role (Chisholm and September, 2005). Chisholm and September (2005) comment that when the data

are disaggregated, a closer scrutiny reveals unequal representation of women based on race and culture, pointing to different socio-culturally-based forms of exclusion and discrimination. In this exclusion lies the type of gender inequality that, especially in South Africa with its political past, gives rise to concerns about the outcomes of the different perceptions that girls and boys hold of gender and its role in society.

Learners from these different socio-cultural backgrounds interact socially in South African schools, institutions and in science classrooms. The challenge for the gender equity debate is how to bring about changes in perceptions of the role of gender in science and science education amongst these learners, given their dissimilar upbringing. Access to education has improved tremendously since the end of Apartheid and the *OECD Report on South Africa* states that about the same number of girls attends schools as do boys. When one reduces the investigation into gender representation in South African schools to a numbers game, Chisholm and September (2005) indicate that by the year 2000, girls had equal if not slightly better opportunities than boys with regard to being enrolled in education and slightly more girls entered secondary education than boys. However, boys fared better at Mathematics and Physical Sciences than girls (Chisholm and September, 2005).

Thus the masculine image of science and science education in South Africa is an outcome of the way in which gender inequality presents itself, given its socio-cultural roots. Chisholm and September's (2005) comment on the gender debate in South Africa that, whilst achieving gender parity is good for equality but only part of the picture, puts the motivation for this thesis into perspective: whilst girls' access to institutions of learning has improved since 1994 and whilst formal South African government machinery facilitates this improved access in the form of equity policies, socio-cultural norms and values prevalent in societies continue to hamper the drive for equality of opportunity for girls and women. The implications for the challenges of science and gender emerging from the South African context are that the strides that appear to have been made in the formal government sector as regards gender representivity are not matched by transformation on the socio-cultural level. On this level, informal dynamics of gender relations continue to reinforce gender inequality, resulting in gender differences in learner selection of Physical Sciences in the FET band of secondary education in South Africa.

The science workplace in South Africa is still beset by the residual effects of the Apartheid system that affected all spheres of life and particularly the participation of women in this field. The lack of participation of women in this field also mirrors the situation that is currently being experienced in other countries – in the First World as well as in the Developing World.

Despite the under-representation of women in the science career field, those women who are currently in the science workplace experience challenges on the basis of their gender. This

contributes to the discrepancy in the numbers of women as compared to men in careers in this field. Aside from working conditions not always accommodating the societal expectations that impact their lifestyles, like mothering, nurturing and caring for babies, and receiving lower remuneration than men, they are at times not taken seriously in the field: their capabilities are questioned, they are sidelined and their opinions disregarded. Ivie and Ray (2005, p.21) note that:

> "...even when working in the same employment sector with the same years of experience, women in physics and related fields on average earn less than men.... Another issue of concern ... is the effect of the climate for women in physics, which in some departments is very chilly. The climate speaks to the everyday work life of female physicists, who are often still told, through actions if not through words, that physics is a man's world."

The barriers that South African women are currently experiencing in the science workplace sector are listed in a DST (2005) report as:

- Discriminatory recruitment practices – sustained by false perceptions that women are not suited to work in the sector and doubts about their competence which are the product of socialisation, the education system, the perpetuation of gender stereotypes and the print and visual media
- Problems in the professional growth and career development of women as a result of discriminatory workplace practices, inequitable allocation of resources, the time constraints mitigating against women, the impact of pregnancy and child-rearing and the lack of gender-sensitive mentoring programmes
- Decision-making management processes which limit women's input
- Discriminatory funding systems which restrict women's progress and promotion in the sector.

The impediments to women's equal representation in the science career field mentioned above reflect and are the outcome of the cultural stereotyping of women and girls to fit into the expected roles that society has ordained for them. At the recruitment level there is the belief that women have to meet more stringent requirements as they aspire to enter certain science fields; their competence is called into question purely because of their gender, even though they might have equal qualifications and experience. Women are reportedly often overlooked for promotion and are allocated 'lesser' responsibilities than men because of stereotyped views of their perceived shortcomings. Women's views are often not given equal consideration to those of men in discussions and when decisions need to be taken. People in management positions follow practices relating to women in the workplace based on societal expectations and their own perceptions of women's socio-cultural roles.

1.2.4 Science in the South African education system: primary and secondary schooling

The General Education and Training (GET) Phase of the South African education system comprises Grades R, the Reception Phase, through to Grade 9. It consists of the Foundation Phase (Grades R to 3), the Intermediate Phase (Grades 4 to 6) and the Senior Phase (Grades 7 to 9). Whilst the South African national curriculum for all schools is under review, Natural Science (NS), a compulsory subject offered from Grade 4, is aimed at 'promoting and developing scientific literacy' and combines aspects of Biology and Physical Sciences. The subject strives to empower learners to 'make sense of the world in scientific terms' and to prepare learners for continuing with the study of sciences in the FET Phase. The NS curriculum lays the foundations for an in-depth study of specific branches of science in the FET Phase, like Biology, Physical Sciences, Agricultural Science, Physics and Chemistry. Whilst not an essential requirement, passing NS is to a learner's benefit, as it is one of the criteria assessed in order to proceed to the next grade and phase.

The FET Phase comprises Grades 10 to 12. A learner has to offer seven subjects and is presented with subject packages from which to select. Usually, learners who select a package that includes Physical Sciences will also be required to offer Mathematics. Physical Sciences deals with aspects of physics and chemistry, although these two can be offered as separate, individual subjects that contain much more detailed content. Offering and passing Mathematics and Physical Sciences at a particular level, as part of passing the Grade 12 examinations, are entrance requirements to most of the science faculties at South African tertiary institutions.

The ongoing challenge is that, in the current South African and Western Cape Province context, where this study is based, learners in the GET Phase of education do not select Physical Sciences as a subject in their academic package for the FET Phase in the desired numbers. The challenging nature of the subject, because of the higher cognitive level required to master it, exacerbates the situation and results in small numbers emerging from the tertiary education level into the science careers field. Women are inadequately represented in this group of learners.

A closer look at girls' and boys' subject selection patterns for the FET Phase reveals the outcomes of the gendering of science in the South African education system. Representation levels for girls and boys in science education start off on an equal footing in the GET Phase in primary schools since Natural Science (NS) is a compulsory subject. The percentage of girls taking Physical Sciences in the FET Phase, as compared to boys, is consistently lower, albeit by a small percentage, as indicated in the table in Figure 1.1 below.

Figure: 1.1: **Western Cape Province: Percentage of Grade 9 girls in the GET Phase selecting Physical Sciences in Grade 10 in the FET Phase**

Years	Enrolment in Natural Science in Grade 9, GET phase			Enrolment in Physical Sciences in Grade 10, FET phase, in the following year			% Grade 9 girls selecting Physical Sciences in the following year in Grade 10	% Grade 9 boys selecting Physical Sciences in the following year in Grade 10
	Girls	Boys	Total	Girls	Boys	Total	%	%
2008	34239	34723	68962	9424	9798	19222	27.5	28.2
2009	39097	37230	76327	9708	9861	19569	24.8	26.5
2010	41983	39724	81707	9267	9254	18521	22.1	23.3
2011	44240	42267	86507					

Statistics obtained from WCED EduInfo education statistics database

Whilst the above picture reflects the position for the Western Cape Province as a whole, the data for the school that was the site of the research (shown in Figures 4.1 and 4.2) indicate a more stark difference and increase in the numbers of boys as compared to girls offering Physical Sciences in the FET Phase of secondary education. The disaggregated data in Figures 4.1 and 4.2 are perhaps indicative of a sub-system that is more homologous and concentrated in its racial, class, cultural and socio-economic characteristics because it reflects a cohort of learners with more analogous circumstances and characteristics. Nevertheless, it highlights the difference in the number of girls as compared to boys entering the science pipeline at the point of origin where choices are made that will reflect in tertiary education and in the science workplace. The data in fact support the contention of this research that formal education is a crucial site where gendered perceptions of science and science education should be countered. Learners' interest in science needs to be nurtured from the time that learners enter the formal schooling system until the choice is made whether to pursue the subject at tertiary level and to enter the science career field. The focus of this research is to investigate particularly the primary, GET Phase of this primary-secondary education juncture in the 'leaky pipeline' and to unpack and analyse the issues that negatively affect the participation rates of girls in science, leading to the under-representation of women in science careers.

1.3 The rationale for this study

The rationale for this research is to contribute to scholarship on science and gender in South Africa given that there has not been a large body of work documenting and unpacking the continued gender inequalities in science. With a look at the gendered perceptions of learners living in the

historically disadvantaged area of Mitchells Plain area of Cape Town, this study would also then provide a specific South Africa context to the apparently world-wide phenomenon of the disparity between men and women's participation in science and science education and highlight the needs for further research in this domain in this country.

In the opening session at the European Commission's Gender and Research Conference in Brussels in 2001, Philippe Busquin underlined the political will of the commission to promote gender equality, integrate the gender dimension in scientific research and address the 'women in science' issue so that "the scientific population needs to better reflect society as a whole" (2002, p.2). The conference focused on the relationship between education, socialisation and gender and raised questions about how girls made choices regarding their involvement in science at school level. Questions were raised as to the reasons why girls chose specific areas of science and whether the reasons for this were general trends or a response to socialisation. The overview further stated that a closer look was required at the image of science where it concerned:

- the attitudes expressed by girls and boys towards different areas of science – since it appears that girls are more interested in biology and health sciences because of their connection to the improvement of the lives of people
- the breaking down of 'deep-seated stereotypes' that develop through socialisation processes that are embedded in the cultural lives of people
- getting down to the roots of 'science imagination' such that learners can be encouraged to participate in and see science as a means to solve the problems of communities
- analysing images of male and female scientists – to establish the patterns of socialisation which lead learners across racial and cultural divides to consistently view scientists as predominantly white and male
- the notion of social control of science where the perception persists that science is for males and where artificial barriers appear to be set up that perpetuate this image, and
- the popularisation of science to enable it to become accessible to a greater spectrum of people and to break down its image as a predominantly male pursuit.

This research is aimed at taking that 'closer look' at what the European Commission's Gender and Research Conference recommended and its research questions are directed at the role that gender plays in mediating learners' perceptions of science and science education, in the South African context.

South African government initiatives across departments and specifically the Department of Science and Technology (DST) are addressing gender issues in science and science education. At the conference in Brussells in 2001, Ms Bridgette Mabandla (the then South African Deputy-Minister of

Arts, Culture, Science and Technology) emphasized that the race issue must not be neglected (Maxwell, Slavin and Young, 2002). Current inequalities, particularly in science education in the different race groups in South Africa, are the legacy of Apartheid and there is a need to bring about equity. Naidoo and Savage (1998, p.96) contend that:

> "We cannot look at issues of science education and disparities in isolation ... changing classroom practices only cannot achieve equity. We must examine school, societal and family practices; perceptions of schooling; political and institutional factors; individual factors; workplace opportunities; and the economic status of the family."

Whilst there are a range of issues confronting girls and women in science in South Africa, the importance of social and cultural factors as they influence girls making choices in science, particularly at school level, needs to be investigated. The lack of a strong enough emphasis on the aspect of the socio-cultural context that speaks to communities in the midst of political transition, in which gendered perceptions of science occurs, is a weakness in the literature on the topic. This is particularly so in the socio-cultural contexts of developing countries where societies are in transformation or where communities are in transition from 'Global North'/First World to South/Third World economic development status.

Literature on the role of gender in science education indicate that there is a worldwide discrepancy in the participation and performance rates of girls as compared to boys in Physical Science in the secondary phase of education (Johnston and Dunne, 1996; Kelly, 1985; Kahle and Lakes, 1983). This has had the effect of creating a discrepancy in the participation rates of women in science careers, which in turn has had ramifications at all levels of society. The manner in which girls are socialised in particular cultures is regarded as a prime reason for this discrepancy. The masculine image of science and the manner in which science is portrayed in the media and popular culture also contribute to this difference in participation rates between girl and boy learners. Whilst girls in Grades 4 through 6 in the primary school still appear to be enthusiastic about participating in and showing an interest in science (Kelly, 1985; Kahle and Lakes, 1983), in Grades 7 through 9 there appears to be a slowing down of interest and a decrease in participation and performance (Clair, 1995; Noonan and Riis, 1983).

There is a need to synergize research on science in South Africa in order to establish where the gaps are in the education, sociological and cultural systems so that the lack of involvement of South African women in science careers can be impacted.

This study focuses on the impact of gender on the educational, social and cultural lives of girl and boy learners and the manner in which this mediates their perceptions of science and science education. This research attempts to reach a better understanding of the debate in South Africa in

order to effect changes which would promote and improve the participation and performance of girls in science and the role of women in science careers.

As a country that has recently emerged from a traumatic period in its socio-political history, South Africa is a Developmental State dealing with the need for rapid economic growth in order to manage the social issues that are surfacing. Economic development brings to the fore the need for advancement in science and technology to sustain growth, which in turn requires an adequate supply of scientists and technicians to advance industrial development. It is in this area that South Africa is lacking and where the drive for gender equality finds its most significant validation. A closer look at the lack of sufficient scientists and technicians exposes the large discrepancy in the number of males as compared to females in the area of science and science education. The acknowledgement of these discrepancies in science and science education participation by official South African governmental as well as civil society structures through published reports is outlined and their interventions are discussed.

The National Advisory Council on Innovation (NACI) and Department of Science and Technology (DST) publication, *Facing the Facts* (2004), reveals the under-representation and lack of participation of women in the Science Education Sector (SET). The Foundation for Research and Development statistics (1996b) for both sexes and across racialised divides shows that only 16% of Black African[2] learners, as compared to 48% of White[1], 20% of Coloured[1] and 37% of Indian[1] learners enrolled for Physical Science (currently called Physical Sciences) in Standard 10 (currently called Grade 12). Black African schools did not offer Physical Science as part of their curriculum, which led to a disparity in the participation rates of the different racial groups in science subjects. The problem of the lack of participation of Black people[1] in science in particular (*RSA Government Gazette*, 1998) emerged as part of the Apartheid legacy of South Africa. The pre-1994 government's policies burdened Black women with the added disadvantage of an even lower status than Black men. This legacy left the country with high levels of inequality and women's disempowerment and gives impetus to the need to investigate the lack of participation of girls in science.

[2] Black African refers to people classified under the Apartheid system as 'non-White' but who do not fall into the categories white, Coloured or Asian. White refers to people classified under the Apartheid system as being from European descent. Coloured refers to a racial grouping labeled as such by the previous Apartheid regime and is a 'mixed' heterogeneous group that was classified as neither Black nor White. Indian refers to people classified under the Apartheid system as coming from the Indian sub-continent. Black people are all those previously disenfranchised under the Apartheid system and includes the categories Africans, Coloureds and Asians. The categories to denote different racial groups are those that the Department of Labour currently uses for the purposes of redress and that still have significance socially in South Africa today.

In answer to the lack of Black learners' participation in science and particularly the gender bias in science participation, the National Department of Education launched the Dinaledi Project in 2001 in 106 previously disadvantaged secondary schools across the country to encourage participation in science and to support the attaining of good results in Physical Sciences and Mathematics at Grade 12 level. The Dinaledi Project was aimed at tracking and accelerating the participation rate of girls in Physical Sciences and Mathematics (DoE, 2001) and supporting them, with a view to improved performance to facilitate the increase in their numbers entering science faculties at tertiary institutions. The school where the study is primarily located, and where I was principal from 1994 to February 2009, participates in the Dinaledi Project. As a Life Sciences teacher, I developed an interest in the issue of girls and science and the 'women in science' debate, furthered by my appointment to the Western Cape Education Department as the provincial project manager of the Dinaledi Project. I sought answers to the following questions: Are learners, particularly in disadvantaged schools, aware of the backdrop to the need for them to engage with science? What are the issues that impact girls' participation in science? Do girls and boys realise the important role that they need to play with regard to gender and how it is influencing the development of scientists in our country?

I was interested in the perceptions that learners had of science and how they perceived girls' and women's roles in science.

In 2004, the Department of Education (DoE) formulated a National Strategy for Mathematics, Science and Technology (DoE, 2004) wherein they acknowledged the importance of promoting the greater involvement of disadvantaged learners, and particularly girl learners, in Physical Science.

National Grade 12 examination statistics of 2006 (DoE, 2008) and the 2000 to 2004 statistics, published in *Education Statistics at a Glance* (DoE, 2003 to 2005) point to a disparity between enrolment and performance levels between girls and boys with regard to Mathematics Higher Grade and Physical Sciences Higher Grade, which are considered gateway subjects to a career in science. Despite policies and strategies aimed at the increasing of the number of women involved in science careers, girls, especially those from Black backgrounds, perform poorly and participate less in science at secondary school level (DST, 2005).

South Africa's National Policy Framework for Women's Empowerment and Gender Equity points out that there is a high drop-out rate and low secondary school pass rate for girls and that "despite innovative advances in South African education, gender stereotypes and women's subordination continue to pose a challenge for curriculum development…" (Office for the Status of Women, 2000, p.12). The DST points out that despite the progress that has been made over the past decade by women in the SET sector, "the fact remains that women in SET tend to be younger and

less qualified than men; receive a significantly smaller slice of the rewards and recognition on offer; and are clustered in certain scientific domains" (2004, p.47).

The need to investigate the lack of girls' participation in science could also be located in the broader vision to extend human rights to all citizens. The strategy to achieve gender equality for women necessitates the transformation of existing institutional values, norms and cultures as they impact girls and their decisions about career choices. The rationale for this study is substantiated by the need to transform society in order to realise greater gender equity and give credence to the extending of human rights to all South Africans.

The interactive social milieu of the classroom is the crucible where attitudes to, beliefs about and perceptions of science are formed. The classroom is also the place where textbooks and the media are used as the mediums through which science is taught. It is the manner in which science is portrayed in these learning and teaching instruments which influences boys' and girls' attitudes to, beliefs about and perceptions of science.

The DST (2005) alludes to a bias against women in the system and points out that there is a need to gain greater insight into this bias and to correct the imbalances caused by the under-representation of women in the SET sector, hence the focus of this study.

1.4 Overview of the thesis

Gender is at the heart of this thesis and Chapter Two discusses the theoretical location of gender in society, science and science education. It expounds on the role that gender has played, and how it is understood in society. The meaning and role of gender stereotypes and the interrelationship between gender and culture and gender and the family are discussed. The evolvement of the theoretical work on the interplay between gender and science, and the manner in which science is gendered, are discussed in the chapter. Gender is key when considering that education lays foundations for social stability on the one hand and promotes social change on the other. This is discussed in Chapter Two together with gender stereotyping, the role of teachers, and social factors that interweave with gender, such as culture, race and class. The manner in which gender differences and inequalities play themselves out in family interactions and in classrooms, including the way in which teachers respond to gender differences, is also discussed in Chapter Two.

Chapter Three provides a literature review of research on gender and science. It explores the role that gender plays in science education, in particular drawing on international and local empirical work. The chapter chronicles the development of a specific focus on research in science education and how science acquired a masculine image that manifests in science education at school. The chapter elaborates on the school environment and its role in the gendering of science and science

education to the extent that differences between girl and boy learners regarding attitudes to, interest in and perceptions of science have been widely documented. The social dynamics of science classrooms, and particularly interaction during science lessons and the way that gender mediates this interaction, is unpacked. The role of science teachers and the manner in which the values and subjectivities they bring with them into the classroom impact on learners' perceptions of science is an issue that is explored in the chapter. The curriculum is the vehicle through which teachers transfer content knowledge but also social norms and values to learners and the use of gender-biased resources like textbooks, science textbooks in particular, is further investigated. The chapter concludes with a discussion of the role of the popular media in promoting gender stereotypes via television, radio, film, music videos and cellular phone imagery.

Chapter Four outlines the methodology of the study. The chapter sets out the process engaged in the design of the qualitative and quantitative tools for gathering the data. The research methodology that was used in collecting the data, including the required sensitivities surrounding research into gender, details about the site of the research, the research aims and questions and the methods of data collection and analysis are explained. The chapter further provides demographic information about the participants and explains the role that the pilot study played in developing the research methodology. Ethical considerations in the conducting of the research are also presented in detail in the chapter.

The quantitative findings are presented in two chapters, Five and Six. Chapter Five analyses the data emerging from the learners' responses to questions related to their interest in, involvement with and exposure to science and the extent to which they are reportedly involved in science activities. The differences in learners' science interests and activities are extended to include science applications used in learners' homes. Learners accessing of scientific information on the Internet and in hard copy format reveals the depth of learners' interest in science and science activities and indicates their willingness to discuss science issues with peers. The data indicating the extent to which learners read science articles, against a background of poor reading skills and limitations regarding access to materials, is analysed and commented upon. This is followed by an analysis of the data indicating the extent of learners' involvement in curriculum-based science activities. Parents serve as an integral part of learners' plans regarding science as a possible career and the data from this section are analysed to establish the level of parental involvement in the aspirations of their children. The increasingly significant impact that the media has in influencing opinions, especially of young people, about science and scientists, is discussed in the light of learner responses to these matters.

Chapter Six continues the analysis of the data showing the learners' responses and perceptions of the dynamics in science classrooms. The data on learners' opinions and perceptions of themselves, their teachers and peers as they relate to science and science education are analysed to establish the trends in their thinking. An important aspect of this analysis is the learners' opinions of their and their peers' performance in science evaluations, as well as the opinions that learners have of their science teachers and the value that they ascribe to science and science teaching. The chapter also analyses the learners' responses to their involvement in extra-curricular science activities.

Chapter Seven analyses the qualitative data of learners' opinions on science and science education, based on in-depth interviews with a group of learners. Learners' perceptions of the role of gender in science and non-science careers were sought to establish the extent of gender role stereotyping. The school and what happens in science classrooms has an important bearing on learners' opinions about the gendering of science. The data from learners' responses in this regard are analysed. Learners' opinions of the reproduction of gender and the gendered notions of science in their homes are also explored here. The chapter also analyses the resistance that some learners, particularly girls, are expressing towards the stereotyped notions of careers in science and other fields. The chapter establishes the foundations upon which the learners' discourse on gender and the gendering of science is based and discusses them thematically. These are the foundations on which learners' statements reflecting their opinions on the role of gender in science and science education are based. They are grouped in the underlying themes of physical strength, intellectual prowess and manual skills.

Chapter Eight presents a thematic analysis of the combined quantitative and qualitative findings of the research. It synthesizes the findings with respect to learners' perceptions of science, scientists and science education and the manner in which gender influences these perceptions. The chapter discusses learners' perceptions of science as reflected in their science interests, activities, performance and science activity in classrooms. It further explores their opinions on science careers, including comments on the influence of parents on their children's choice of careers, especially as it pertains to science. The chapter also reaches conclusions that can be made from the study around gender and learners' perceptions of science and science education. Based on these conclusions, it provides recommendations for meeting the challenges presented by the under-representation of girls in science education and women in science careers. In this respect, conclusions that reflect socio-cultural influences, like the role of schools and educators, the role of parents within social change, and the challenges faced by women in the science careers landscape, are made. Conclusions are also drawn about the trends emanating from learners' responses regarding their perceptions of what is taking place in the science classroom, with particular reference to learning and teaching support

materials like textbooks. Learners' perceptions of their transfer from the GET to the FET Phase of the education system and how this impacts on their perceptions of science and science education are summarised. Conclusions are further reached about learners' perceptions of science careers and the effects of socio-economic factors on these perceptions. The interventions with respect to gender in the science and science education sector by the South African government thus far are placed into context and critically reflected on. The chapter concludes with recommendations for government policies and practices in science education and the larger social institutions that overlap. The purpose of these recommendations is to manage the practical effects of learners' perceptions of science and science education for all the stakeholders and to assist in the transformation of the role of gender in the science and science education sector as it strives to meet the challenges of the gender inequalities that prevail.

1.5 Concluding remarks

The context of the impact of the gender of learners on their perceptions of science and science education in South Africa is permeated by the influences of the social environment of their lives, including the lingering effects of the policy of Apartheid and the effects of historical and patriarchal social relations. It is apparent that a situation has developed in South Africa where girls are lagging behind boys in their participation in science at the FET level, owing to the cumulative effects of socialisation and schooling. These are some of the factors that may contribute to a lack of participation of women in science courses at tertiary level and in science careers beyond tertiary education.

The South African government's formal interventions in the form of the Gender Commission and various other strategies to combat the problem are evident. They confirm recognition of the problem and the need for corrective action. However, whilst progress is being made in the numbers game, as evidenced by parity indicators, the quality of the participation is at issue. This thesis intends to unpack the concerns that inform the debate surrounding the reasons for the discrepancy in the participation rates of girls as compared to boys in science in the FET sector, the tertiary science education sector and the science careers field. It also seeks to unpack the reasons for the apparent differences in the quality of girls' and women's participation in the science and science education sector.

CHAPTER TWO

Theorising gender in science

2.1 Introduction

The emergence, growing significance and importance of the outcomes that gender differences bring about in science and science education are indicative of the more active role that women are assuming in the economic, political and social life of communities. Perceptions of and reactions to the evolution of the role of women to more than just nurturers, caregivers and mothers have their outcomes in social practices in families, education and the workplace and in the way in which women are expected to fit into their 'place' in society.

The discrepancy in the participation and performance rates in science between men and women continues in this 21st century. Nancy Gibbs (2009, p.32) in a recent *Time Magazine* special report titled 'What Women Want Now' confirms this and maintains that despite progress in the employment patterns of women:

> "It is still true that ... whole swaths of professions ... remain predominantly male; women are about 10% of civil engineers and a third of physicians and surgeons but 98% of kindergarten teachers and dental assistants..."

The overall goal of this chapter is to provide a theoretical framework for the manner in which gender has been thought of in science. The chapter starts off by elaborating on the role of gender in society. Social constructs about gender are the vehicles through which society's expectations are confirmed. These constructs limit the thinking of both girls and women and boys and men as regards their roles in society and their place in education, the world of work, economics and politics, thus reproducing gender divisions and the unequal power relations that these underline and facilitate.

A discussion of the concept of gender and what it means in society is important, since it lays the groundwork for the use of the term throughout this thesis. The creation and use of gender stereotypes and the manner in which these are used in cultural and family settings are discussed. The chapter aims at placing gender inequalities stemming from the roles of men and women in society into a theoretical framework that explains and contextualises gender role stereotyping, gender and culture, and gender and the family.

In the section on gender and science, attention is drawn to feminist analysis of the nature of science, the manner in which science is practiced and the way in which science is transmitted through education to successive generations. A feminist analysis specifies ways in which the masculine image of science can be countered and the effects dissipated to bring about a more girl-friendly science that is more inclusive and that moves away from its hegemonic masculine image.

The manner in which the gendered nature of science is transferred in science classrooms by teachers and the curriculum is partly a consequence of the role that gender plays in education as a whole. A discussion of the manner in which gender roles are reproduced through education and teachers, who bring their own gender attitudes and perceptions into classrooms and influence learners' construction of their gender identities, ensues. Throughout the debate, the roles of poverty, class, race and ethnicity as local environmental and contextual factors can never be discounted; they play a pivotal role in intersecting with and often compounding the effects of gender role stereotypes on girls' aspirations and boys' perceptions of gender in the science domain.

The theoretical framework discusses the social forces that facilitate the internalisation and reproduction of the gendered nature of science and science education. Current theories describing how knowledge is constructed by learners encapsulate the ways in which science is gendered. It is within these processes that the gendering of science is reproduced. This thesis confirms this, details the processes and key sites where it occurs, and sets out to expose how this continuing gendering of science transpires. In exposing this perpetuation of the gendering of science, the point is made that science, and science education in particular, has become a battleground where the gender debate crystallises, whether in science classrooms, science laboratories or science careers. The curriculum and teachers' roles in the science classroom have been placed under a microscope and have become a focal point for analysing the manner in which education reproduces stereotypical and unequal gender roles in science.

2.2. Gender and society

2.2.1 The concept of gender in society

Society, via norms and values that are created in cultural settings, constructs roles with masculine and feminine attributes to which people subscribe. This social construction of gender roles is responsible for the expectation and the image of girls as mothers and nurturers and laid the foundation of the impression promulgated in classrooms that science is for boys. Social theorists noted that the biological-sexual differences between men and women contextualize their role and give rise to the view that "men and women have certain natural predispositions on which a social superstructure is constructed" (Elliot, 1986, p.27) by society.

The significance of the concept of gender as a social construct, and its impact on the evolution of society, culture and subsequently on science, needs to be reflected upon when the influence of social variables on science and science education is considered. Haslanger (2000), in confirming a social constructionist position on gender in education, argues that the concept of gender cannot thus be approached in a purely descriptive mode that contains an understanding of how

people use it. In further unpacking Haslanger's use of the term 'descriptive mode' and relating it to science, Rolin (2008, p.1114) argues that the description serves three purposes:

> "First it enables one to understand how scientific activities can become gendered. Second, it contributes to one's understanding of how inequalities between women and men are maintained. Third, it enables one to formulate testable empirical hypotheses about gender and science."

This interpretation of gender as it relates to science leads to an exploration and identification of different styles of doing science, implying that there is a men's and a women's way of doing science. The use of the terms 'gender' and 'sex' in the literature on the role of gender in science and science education necessitates the need to distinguish between the terms because it has been key to feminist thinking around gender. The definitions of the term 'gender' hinge around a social dimension and point to the inter-relatedness and dependency of the concept on power relations in society (Chodorow, 1978; Elliot, 1986; Beall and Sternberg, 1993; Bonthuys and Albertyn, 2007). Whereas Elliot (1986) points out that people use the term to differentiate between the sexes, Beall and Sternberg (1993) refer to it as a social construction by which people define social roles and Rennie (2000) goes further and indicates that the construction of gender is dependent on social variables like race, ethnicity, religion, class, language and lifestyle. Bonthuys and Albertyn (2007, p.21) indicate that gender is used primarily as a sociological label in relation to sex that is assumed to be biological:

> "...gender signifies the differences which societies and cultures ascribe to people on the basis of their sex."

The term 'gender' has acquired a greater dimension from just being used to differentiate between the sexes to having a "wider understanding ... as a set of meanings and discourses" (McDowell and Pringle, 1992, p.11). The term 'sex' has a biological and physiological context and is used to refer to women and men as biologically differentiated beings, whereas 'gender' describes social and cultural differentiation (Elliot, 1986; Bonthuys and Albertyn, 2007). Gender in this thesis is understood to be a social construct and will thus be used also to refer to the meanings that social groupings associate with the term. This thesis accepts, as in constructivist thinking, that learners construct their understanding of gender and their own gender identity within social and cultural concepts, including those offered by formal education.

The social meanings attached to gender, and the practical manner in which these meanings play out for men and women and girls and boys in society, change as the demands of society change. In the Western world, the changing socio-economic environment in the post-Second World War period led to the role of women being realigned from that of a traditional housewife-mother to one of more involvement in spheres of influence traditionally dominated by men (Elliot, 1986). This realignment gave rise to the need for the imposition of gender equity policies as societal pressure

was created for equal treatment of men and women in the workplace and other spheres of life from which women had previously been alienated – including science and science education. In Western European and North American contexts, the attainment of the rights of women came into sharper focus as the post-Second World War period saw a request for women to allow men to take back their jobs when they returned from the war. However, by this time, rapid industrialisation meant that women were needed to stay in the growing labour market to support increasing production. This impacted on their traditional role in the family and contributed, together with other factors, to the growing debate about their role in society with regard to the division of labour (Elliot, 1986). Women's role in society came under scrutiny, resulting in tension between traditionalists who expected women to 'go back to the kitchen' and 'modernists' who saw women being integrated into the modern economy and participating as equals in society. This latter way of perceiving the role of women was strengthened by the women's liberation and empowerment movement. Nevertheless, the gender stereotyping of women's roles had the effect of making women and girls in classrooms believe that their career choices needed to fit into traditional and socially expected roles. The feminist and women's empowerment movements had to compete with the traditional norms according to which girls are raised and the gender stereotypes that are cultivated within these cultures; thus, contending with socio-cultural influences becomes a challenge in countering the effects of the gendering of science and science education.

Interventions toward gender equity in science and science education need to take cognisance of this socio-cultural context within which society functions and learners learn, for it is within this context that interventions will bring about the required paradigm shift and have a lasting effect. Intervention initiatives aimed at bringing about change in the gender disparity that exists in science and science education will need to recognise the influences of family, peer groups and the media and bring these social institutions on board if programmes are to succeed. In this regard, consideration of the norms, values, languages, customs, beliefs, ceremonies and symbols in which learners are immersed, forms an important backdrop to the development of learners' opinions with regard to science and science education.

Social Learning Theory contends that the relationship between the developing child and the parent, as one of the socialising agents, forms a dynamic, interactional unit (Beall and Sternberg, 1993) and that the child also learns all the time from the broader social environment, including imitating characters from the print and electronic media. Gender is thus socially constructed but it is also argued that the child is not a passive recipient in the process of the transference of socio-cultural norms and values. This thesis aims to show that the learners who participated in this research are 'recipients' but also active agents in this transference of socio-cultural norms and values, a process

that forms an integral part of their developing a gender identity of their own and a gendered view of science. It is this thesis' premise that education and the media, as agents of socialisation, reproduce the status quo with regard to gender through social institutions of the family, culture and through social stereotypes propagated at all levels. Drawing on Burr's (1995) outline of basic tenets of the social constructionist position, I am of the view that learners' actions and the expression of their views in science classrooms, as mediated by the manner in which their gender has been constructed and interpreted, have developed through human experience as influenced and translated through language. They have not merely adopted as objective precepts perceptions about science that they encountered in society. These perceptions are culturally and historically specific such that they are ethnographically situated in the contexts of the communities in which learners grow up. In this sense, it is to be expected that learners who grew up in environments where the effects of Apartheid are still apparent would express gendered views on science and science education that have been powerfully overlaid by the effects of that policy of racial classification.

Social interaction with peers on school playgrounds, with other learners and teachers in school science classrooms and with siblings, parents and significant others in homes thus mediate and influence gendered, raced and classed perceptions of science and science education. It thus becomes necessary to investigate social settings where interaction takes place: in families, on school playgrounds and particularly in science classrooms. These classrooms are where the communication between teachers and learners maintain and reproduce the dominant image of science and scientists. This thesis sets out to investigate how gender as a social construct, and as intersecting with race and class, mediates the perceptions of science and science education of learners.

2.2.2 Gender and culture

The definition of 'culture' in the *Encyclopaedia Britannica,* one of a variety of definitions based on different perspectives, states that culture includes:

> "...language, ideas, beliefs, customs, taboos, codes, institutions ... rituals, ceremonies, and symbols. (http://www.britannica.com)"

This definition contains reference to some of the fundamental aspects of culture that have a close connection to the manner in which gender intercedes in learners' perceptions of science and science education. I regard language, in the form of oral as well as written communication, as the prime and most pervasive tool by which perceptions of gender are communicated during social interaction. Gendered terms and phrases and the meanings attached to language, aside from the use of language to communicate gendered ideas and stereotypes, convey perceptions of gender. Common beliefs containing gendered perspectives held in society, that have been 'passed down' from

previous generations, permeate the content of social interactions and are passed on through oral and written communication. Boy and girl learners' communication, as reflected in this thesis, whether oral (as in the semi-structured, in-depth interviews) or written (as in their responses to the survey questionnaire), is a significant indication of their perceptions of science and science education.

Gender stereotyping is a social practice that can be classified as one of those 'codes' and 'beliefs' that is passed down through social interaction. In defining stereotypes, Kende (2000) states that they originate when differentiating characteristics are ascribed to all group members – regardless of whether they possess the characteristics or not. In adding to the above definition, Bonthuys and Albertyn (2007) refer to its normative and descriptive elements – that they describe how certain people are but also prescribe how they should behave. The gender stereotyping of the boys and girls who participated in this research occurred in their families, where they were socialised, in their schools, where their gender roles were propped up by educators delivering the curriculum, in their socio-cultural settings, and via the media that they engaged with, where the connection between gender roles and careers is affirmed. As social constructs that are pervasive in social systems, stereotypes have a powerful impact on learners' perceptions of various issues in society and more specifically, in terms of this research, of science and science education.

The customs of various cultural groupings and cultural institutions are transmitted through behaviour patterns. The learners in this research subscribe to cultural groupings and institutions that contain rituals and actions, built up through generations, with built-in gender biases that influence their perceptions of science and science education. The many cultural ceremonies and symbols convey to them messages that influence their perceptions of gender as it pertains to the particular social grouping to which they see themselves connected and to whose norms and values they adhere. Society thus maintains and propagates gendered practices via the transmission of culture; learners, who then enter school classrooms with preconceived notions about stereotyped gender roles and gendered division of labour, express themselves in terms of their experience of these cultural practices. The current gender-based disparity between the perceptions of girls and boys and men and women regarding participation in science and science education insists that institutionalised attempts be made to counter these notions. School classrooms are probably the most significant sites of this struggle. In this respect, a British study of gifted learners (Freeman, 2004) refuted innate ability differences between boys and girls in examination results but highlighted strong cultural influences as the reason for the differences in results. Further, whilst recognising small biological differences between girls and boys as a reason for the discrepancies in achievement, Freeman (2004, p.11) ascribed the larger gender disparities in results to differences in the socialisation experiences of girls and boys and acknowledged the power of social effects in bringing about these differences. The

socio-cultural context of the role and rights of women in Third World, underdeveloped nations has come under particular scrutiny in this regard (Bonthuys and Albertyn, 2007). This particular context generates specific perspectives when gender issues in Third World countries are explored and more so in terms of this research that deals with gender and the perceptions of science and science education in South Africa since this country is regarded as comprising African, Third World communities as well as Westernised, First World communities. The location of this research could be construed as having been undertaken in a First World community with the understanding that there are class differences in First World communities, an issue that will be taken up later in this research. Bonthuys and Albertyn (2007, p.71) sum up the issue thus:

> "The dichotomy between culture and gender equality, which underlies the debate between cultural relativists and human rights universalists, disadvantages both western and African feminists."

Clearly then, the cultural practices that are focused on women, in the communities from whence the learners in this research come, bring culture pertinently into the 'women in science' debate, and into the focus of this research of learners' perceptions of the role of gender in science and science education. As social institutions, the learners' family units are sites where these cultural practices are internalised and transferred; the manner in which gender is mediated in their families plays a key role in learners' internalisation and development of their gender identity.

2.2.3 Gender and the family

The family, as the basic unit through which socialization occurs (Mitchell, 1973), provides the site for social interaction where perceptions of gender are reproduced by the affirming of stereotypes and the establishment of accepted patterns of gender behaviour. The families of the boys and girls in this research thus constitute their first informal learning environment and their parents their first teachers. Researchers have commented on the influence of family on learning opportunities. In this regard, the value of exploiting opportunities to learn outside of the formal school environment at an early age is confirmed in the findings of Sui Chu Ho (2010) when she examined the influence of the family on adolescents' science learning. Sui Chu Ho (2010, p.409) found that performance in scientific literacy could be improved by parental investment and involvement in their children's science learning and that:

> "...watching TV programmes about science, reading books on scientific discovery, watching, reading or listening to science fictions ... were found to be highly effective activities for promoting children's achievement and self-efficacy."

Chisholm (2004) confirms the above statement and comments that it is through social interaction in families, and especially communication from parents to their children, that gender and

other social stereotypes are transferred. Gender differences and what these mean in society are passed on to children by parents. Jacobs and Eccles (2000), confirmed by Bleeker and Jacobs (2004, p.98), contend that:

> "Over time, children construct their own self-perceptions and interests, based on their parents' messages, integrate these beliefs into their self-systems, and ultimately, use such beliefs in future task choices..."

The gender role stereotypes held by the family members of the learners in this research thus influenced their socialisation process and continue to have implications for their schooling experience. The important link between parents and children, especially with regard to its impact on academic achievement, is well established in the literature (Bhanot & Jovanovic, 2009; Frome & Eccles, 1998; Toldson, 2008,). Family members send different messages to boys and girls about girl and boy behaviour, though, and Bhanot & Jovanovic (2009, p.43) state that because parents engage with their boys and girls differently with regard to schoolwork:

> "...it is conceivable that these differences are the means by which parents' differential ability beliefs are communicated to boys and girls."

The interaction that takes place in family life thus presents an important framework for the social construction of science and science education perceptions amongst boys and girls. Children internalise these beliefs, use them in constructing their own gender schemas and then express opinions about science and science education in terms of these beliefs. Mothers and fathers convey to their children their perceptions of gender and science in expressing gendered views whilst supporting children's science-related activities and their aspirations in terms of science careers. The potential family influence on the gender behaviour, differences and beliefs of the boys and girls in this research is tempered, however, by the economic and socio-cultural environment in which they continue to be raised. In this regard, Arnot et al. (1999, p.28) comment that:

> "Gender differences appeared narrower where students have the greatest cultural and material advantages and sharpest where their parents were more socially disadvantaged."

2.3 Gender and science

The contextual issues that frame the gendering of science have been cited by Baker (1998) as the historical, the participation rates of women, the influence of schools, the influence of the home, socio-cultural barriers and the nature of science. Baker (1998) points out further that these issues stem from the disparity in participation and performance rates of women in science, particularly in science education.

The male image of science and the manner in which women have been sidelined and excluded from the science mainstream in its philosophy, epistemology and practice, epitomise the

larger debate of the different and unequal manner in which women are perceived in society through its socio-cultural practices and the way in which these affect the lives of women and girls. The foundations on which the philosophy of science was built stem from the 'hegemonic' aims of power over matter and the elements, and from the pursuit of technologies like those that are exploited to make war. From the earliest stages of its development to its current status, this philosophy of science exhibited "far too intimate connections" with power (Harding, 1991, p.48) as noted by postmodernist feminist thinkers. The "partiality and distortedness" (Harding, 1991, p.47) of the epistemology of science became apparent when women were factored into the way in which research in science was conducted. Harding further points out that when the characteristics and experiences of women's lives are held up to the "dispassionate, disinterested, impartial, and concerned with abstract principles and rules" (Harding, 1991, p.47) nature of science, then the contradictions begin to expose the one-sided, masculine image of science as a discipline. The practice of science, as evidenced by the continuing image of scientists as white males in white coats, continues to be seen as a male domain for male pursuits. The effect of this is the discrepancy in the numbers of male and female scientists.

The gendering of social roles that leads to people's fitting into expected behaviour patterns and careers has permeated the domain of science, also in South Africa, and thus science is widely regarded as having a gender bias; it is perceived as a male pursuit in its conceptualisation, activities and the careers that it gives rise to. This precipitated an increasingly vociferous debate and a movement to bring about awareness of the male image of science and corrective action to realise equity in science. The debate and the movement developed in response to the Western world's science: Harding (1991) maintains that it had developed a mindset based on culturally distinctive belief patterns that caused scientific rationality, from "the perspective of women's lives" (Harding, 1991, p.3), to appear to be frequently irrational. This science mindset displayed mainly male perspectives, promoted mainly male participation and was masculine in its approach to the epistemology of science.

The focus of the 'women in science' debate on the under-representation of women in science and its activities, because of its focus on the marginalisation of women in the science mainstream, gave credence to movements in the counter-culture of science. These counter-cultural movements engendered criticism of the aspects of science that have a negative effect on society. These movements, also active in South African communities, include animal rights groups, environmental groups and women's reproductive health groups that organised against the impact that 'bad' science was having on the existence of other living species and organisms and on the intricacies of aspects of women's reproductive health. Harding (1991) maintains that the increasing use of technologies in aspects of women's reproductive health signifies their loss of control over what happens to their

bodies in this aspect of their lives and typifies their "lack of power in the social order" (Harding, 1991, p.34). For feminists especially, science as a discipline thus became a contested terrain, especially in its epistemology and the negative effects that the technologies it spawned had on society and especially on the lives of women and girls. The boys and girls in this research continue to be 'beneficiaries' of these negative effects. Their responses in interviews and to the survey questionnaire reflect this.

The general acceptance of the view that science has become male-orientated, to the detriment of female participation and to the extent that women remain under-represented in science, necessitates a discussion of feminism which grew from the standpoint of the unequal status and participation of women in aspects of social life. Feminism and specifically the feminist standpoint on women's participation in science has positioned itself at the heart of the debate. It seeks to pull together its different aspects into a coherent understanding of the reasons for the state of affairs with regard to women, gender and the perceptions of science and science education. Sharon Crasnow (2008, p.1107) puts it succinctly:

> "Feminist epistemology is one of a group of approaches in science studies that urges us to recognize the role of the social in the production of knowledge."

Crasnow's comment above points to the recurrent theme in feminist views on science: that women 'do' science differently; that this way of doing science, whilst not moving away from the formal requirements and precepts of research, is closer to the social implications of science and science education; and that this needs to be recognised. Reference to a 'women's way' of doing science goes to the core of what feminists and science critics are maintaining: that the current manner in which science is 'done' needs to be responded to, not only for the sake of promoting greater women's participation in science but to question and challenge the very basis of the logic of science and the foundations of science as a discipline – that is, how science is thought of and 'done', which gives it that male image. Harding (1991) refers to a wide spectrum of gender relations, including male supremacy, that are supportive of masculine science, as the more personal, practical outcomes of challenges that are at the core of why science is regarded as a male domain. Harding identifies these structural obstacles as sexism and androcentrism which are the real cause of the marginalisation of women and their achievements. Coupled with these challenges that Harding (1991) terms 'structural obstacles', women in various parts of the world also face the added consequences of racism, poverty, the effects of social stratification and being part of a Third World, developing economy on their participation and performance in the science domain. Whilst there are situational differences for women in various communities, the inequalities that racism, poverty and social class generate have the effect of further limiting the access of women to science, limitations that they would in any case

experience simply because of their gender. These added drawbacks compound the marginalisation that women and girls face in the science domain. The effect of these added disadvantages experienced by women in science prompts Harding (1991, p.197), in referring specifically to African American women, to comment that:

> "It is amazing that any African Americans achieved scientific careers in fields other than medicine prior to World War II when one considers how severely limited graduate science education was for them."

The 'women in science' debate has gained prominence. The spread of its underlying theme of challenging and countering male-oriented practices to broader socio-cultural activities is pointed out by Richmond et al. (1998, p.916) who show how feminists have demonstrated science as growing from a Western, male tradition that "celebrates objectivity, distance, power, and technological progress that is often used to support social injustice and the status quo". Feminist theorists are challenging male dominance as an aspect of the patriarchal system. According to Millett (1970), the system sustains itself through socialisation by families, schools, the media and learning resources. This challenging of male dominance is reflected in the responses of some of the girls participating in the semi-structured, in-depth interviews, as discussed later in this thesis, and is an indication that the rhetoric of women's empowerment has filtered through and is influencing the views of girls in schools in South Africa.

At a time before women's empowerment gained prominence and there were few women scientists, men crafted the scientific approach requiring dispassionate observations and the removal of subjectivity in experimentation with results and conclusions based on the analysis of facts. The scientific method consisted of the unemotional conducting of chemical and physical processes by the scientist dissociating his personal self from the process except to interpret results based on observed facts. This clinical approach located itself in the hegemonic need for power over matter and led to the development industries primed on production of material goods to sustain 'progress' at the expense of the social effects that scientific progress and industrialisation was having on the environment and society. A case in point is the development of the iconic computer (and its offshoot, the cellular phone), first used in warfare before causing a revolution in communication with the birth of social networking via technology. The social injustice that was a consequence of the warfare that flowed from this hegemony was what feminists railed against. Increasingly feminists saw the social system sustain this male-dominated world view, with science as its mainstay, through socio-cultural forces.

In focusing on the gendering of science, feminists realised that science had increasingly become for them "an increasingly powerful tool" through which to critique social issues like the role of women in society (Kleinman, 1998, p.838). Feminist critiques of science have placed the

inaccessibility of science to women, because of its nature and practices, in perspective and have provided as reasons for women's feeling "disconnected" from science pursuits (Richmond et al., 1998, p.916) that it does not allow for their perspective and their way of 'doing' science. Harding (1991) points out that the sidelining of women in science rendered them outsiders to the dominant institutions in the natural and social sciences.

Feminist science and teacher educators, Richmond et al. (1998), contend that science has been narrowly and powerfully shaped and has marginalised significant groups, as reflected in the findings of this thesis also. They used assignments in their study to assist students to "deconstruct scientific knowledge and construct alternative views of science and science education that are gender and culture sensitive" (Richmond et al, 1998, p.897). In this regard, in a study that analysed data on the distribution of men and women in science and which looked at the ideological factors affecting who pursues a science career, Kleinman (1998), in her conclusion, confirmed that science is a masculine domain and that this powerfully shapes who pursues it. Kleinman (1998) also noted that in appraising science, feminist scholarship has demonstrated that science is gendered as a masculine domain and that feminists have drawn attention to ideological and socio-political factors that continue to limit women's participation in science and other sex-role-stereotyped, traditionally male pursuits. Elliot (1986) contends that male dominance is promoted by images of male domination as reflected in the media, literature, art, children's reading materials, myths and folklore, and in the language that we use.

Despite the progress that has been made, the under-representation of women in science and science education continues (Intemann, 2008). This has kept the debate at the forefront of feminist thought on the role that gender plays in science. In her introduction to a series of articles on Women, Science Education and Feminist Theory, Pinnick (2008, p.1053) sets the scene with her comments on the women in science debate by mentioning the conclusions that have been demonstrated:

> "...that women have a distinct standpoint on nature, that women are marginalized, and that women learn best about nature in a distinctive and gendered way."

Feminist Standpoint Theorists contend that "knowledge is socially situated" (Harding, 1991, p.119). From a science point of view, the implication is that gender differences would entail differences in perceptions of and approaches to science. Knowledge facilitates the functioning of society and scientific knowledge, generated through male-dominated scientific methods, spawns processes that promote the male stereotypical manner of doing things. Feminists argue that women's involvement in scientific knowledge production may foster a perspective of caring and nurturing that makes for a more sensitive, more environmentally friendly and ultimately more accountable society. According to Landau (2008, p.1082) this theory "claims that people are socially positioned, and

frequently differently so", implying that men's and women's differing positions influence their knowledge differently. Roychoudhurry et al. (1995) have a similar understanding of the Feminist Standpoint Theory, arguing that it contains a common premise that the different social experiences of men and women lead to different ways of looking at life and interpreting events and thus differing standpoints. The implications of the Feminist Standpoint Theory for this research is that the differing life experiences of girl and boy learners could lead one to expect that they would experience science differently and thus have differing viewpoints of science and science education. Roychoudhurry et al. (1995) further point out that it is not surprising that women are strangers to science because of its apparent incompatibility with women's standpoints, a view also shared by Kelly (1985). This perspective gives credence to the marginalising of girls in science classrooms because it is premised that science, in its current form, operates outside of the lived experience of girls.

These theories of women's involvement in science provide a backdrop to the challenges that girls experience in science education. Tsaparlis (2001, p.2) argues that behaviourism, realism, the personal constructivism associated with Piaget and the social-constructionism associated with Vygotsky all form part of the development of an understanding of science education despite Mathews's (2000, p.493) referring to the comment that the argument of critics of constructivism in science education is that:

> "Constructivists pay attention to how students learn ... but not to what knowledge (wrong or correct) they construct."

Tsaparlis (2000, p.3) concludes that:

> "...all theoretical perspectives in science education are useful and precious tools for advancing our understanding of the learning and the teaching of science."

The implication for this thesis is that boy and girl learners may have different ways of 'doing' science; this stems from their identities and gendered perceptions of science and their views on the use of science in society as is translated by their science interest, involvement in science-related activities, as well as their career aspirations, or not, in science fields. This thesis also contends that what inhibits girls' science involvement to the same level, at least, of that of boys, is the view generated over centuries that science is a male pursuit. I would argue that learners are influenced by society's gendered configuration of the science world. In constructing their gender identity they are inadvertently also 'buying into' society's views of the gendered nature of science. The education system is contributing to this construction with the influence of science teachers, science textbooks and gendered science curricula and its scientific method, which it compels learners to reproduce through compulsory evaluation processes.

2.4 Gender and education

This section focuses on gender and education. It foregrounds how education has been seen as a key site for reproducing and legitimising normative gender roles and power inequalities as reflected in society at large. The need to focus on the debates in this respect is important since, in education, socio-economic inequalities based on power are being confirmed.

2.4.1 Gender roles in education

Gender continues to play an important role in the culture in which the boy and girl learners participating in this research are raised. The manner in which this culture is transmitted via socialisation influenced their world view and educational experience. In this regard researchers have theorised about the manner in which gender is interpreted and portrayed by parents, teachers, role models, the popular media, the home environment, and society in general. Education in particular has been understood as a key site for the transmission of normative gender roles in multiple ways (Stanworth, 1981; Baker, 1998; Howes, 2000; Erden, 2009). Sadker and Sadker (1994) argue that boy and girl learners' educational experiences are different, despite their being socialised in the same environment. This difference ensures that the role of gender in education continues to be a contested terrain. Erden (2009, p.409) confirms this ongoing contestation with the comment that:

> "...gender equity in education has become one of the most controversial issues in recent years."

The role of gender in education forms part of the study of social change; the processes and contexts involved in it continue to be researched. One of the facets that is concentrated on in this debate, and is focused on in this research, is whether girl learners are getting equal consideration, treatment and access to education. In focusing specifically on the influence of schooling on the gender equity debate, Baker (1998) lists traditional instruction, inequitable classroom interaction, teacher expectations and judgments, curriculum materials, and fewer opportunities to learn as limitations on girls' achievement in science classrooms. The above detailing of Baker's (1998) listing of the gendered atmosphere of science classrooms leads to a situation where girls are given inadequate opportunities to learn. By referring to traditional instruction Baker (1998) alludes to the situation where teachers teach from the front of the class and where learners sit in neat, orderly straight rows – this perpetuates the power relations in science classrooms and stifles spontaneous, non-threatening discussion. During this inequitable classroom interaction, the judgments that teachers make based on their expectations are characterised by science teachers who would arguably ask boys questions or to do experiments before asking girls. Baker argues that during science lessons boys would also be allowed more time to respond to questions than girls and that the curriculum

materials that are used in science classrooms, especially science textbooks, are male-orientated in the language used in the text as well as in the images that are prevalent in the content. The aspects of interaction in science classrooms that Baker (1998) mentions need to become the focus of interventions toward 'gender-free' science classrooms.

What makes a change in perception towards gender in education particularly challenging is that the debate is beset by a conundrum, the paradoxical dualism in the purpose of education – that of providing continuity on the one hand and fostering change on the other, of maintaining the social order while still preparing for social change. Teachers and the curriculum are reproducing the status quo with regard to gender roles; yet this needs to change to accommodate the need for equal rights with requisite gender equity initiatives. This dualism is the 'hidden curriculum' that is also reflected in the responses of learners in the survey and the semi-structured, in-depth interviews of this research. Its deliverance means that learners are schooled in the norms and values of society regarding gender and yet need to be prepared for and be part of the changes that occur in society, as it comes to terms with issues like gender equity, globalisation and world-wide environmental change. In discussing this dual function of education in the context of social change, Chisholm (2004, p.13) comments that:

> "But an emphasis on the role of education as an agent of transformation at the expense of a consideration of its role in maintaining the status quo is equally inadequate."

The clients in the education system, its learners, continue to enter the education system with gendered perceptions that have been imparted to them via socialisation. The society that learners are raised in is fraught with gender bias. Since education acts as an agent both of social reproduction and of transformation, therein lies the challenge with regard to gender. Stanworth (1981, p.14) confirms this replicating role that education plays with regard to gender:

> "To grasp fully the relationship between gender and schooling, it is necessary to have a framework in which to locate the place of education in society. ...a number of useful insights have been generated. These imply that education – far from being, as it was once ironically called, "an equality machine" – tends to act as a vehicle for the reproduction of patterns of subordination and domination which characterize our society."

Where there is gender stereotyping and actions adhering to this that lead to social inequality, learners have to be schooled, via the 'hidden curriculum', to change attitudes and perceptions since it is through the hidden curriculum that accepted gender roles with their accompanying power inequalities are reproduced.

2.4.2 The role of teachers in normative gender roles

Teachers, as the prime deliverers of the curriculum, play a crucial and seminal role in the development of learners' gender perceptions, not only through the teaching strategies that they employ but also through their own actions in this domain. They are the primary agents in schools that reproduce the status quo in society with respect to values and norms regarding gender. What needs to be pertinently remembered is that teachers, as products of the society themselves, have their own perceptions of gender; they act in ways that reflect these perceptions, further complicating the 'continuity and change' function of education and impacting the education system's obligation to bring about gender equity in education. The actions of teachers and their learners during interaction that takes place both in the classroom and in the informal settings of schools, like playgrounds, change and recreate the perceptions of gender of the learners. In this respect Connell (2006, p.viii) talks about the:

> "...very complex tissue of gender beliefs and practices that operate in particular situations, and the varying ways young men (for instance) draw on them in constructing ways of life."

Teachers, given their own gender and the perceptions of science and science education that they bring into the classroom, complicate the 'gender in education' issue even further by promoting and reproducing gender roles, with their power inequalities, in their delivery of education. This will be elaborated on further in the next chapter. Despite the significant role that teachers play in reproducing gender inequality in classrooms, Weiner (1994, p.71) points out that teachers cannot be held entirely responsible for this and "educators should rather work at what they can to re-educate society". Teaching strategies and the extent to which they are infused with science teachers' gender perceptions constitute an external influence on learners' perceptions of science and gender. Learners are also influenced by the own internal 'constructs' that they have cultivated about gender and they develop opinions of what constitutes a particular gender identity.

The implications of the above-mentioned perspectives are, as this thesis maintains, that girl learners especially, enter science classrooms with gender perceptions (including gender perceptions of science) that, although a 'work in progress' having been impacted from various sources, put them at a disadvantage of participation. Science teachers are an important component in mediating the different environments that learners come from, in the interests of a gender-free science classroom. Naidoo et al. (1998) go further and contend that, besides curriculum content and style of delivery, policy change and the redistribution of resources are important aspects of gender equity. Girls' gendered perceptions of science have been illustrated empirically. In their study to investigate the cultural stereotypes of six Grade K (Kindergarten) learners relative to their self-perceived

competencies, Andre et al. (1999) were surprised that many of the stereotypes with regard to science were already present at the younger Grade Levels 1 to 3 and suggested that interventions be targeted at younger grades via the curriculum. Of significance is Andre et al.'s (1999) comment that, though their data suggest that girls and boys like the areas of Biology and Physical Sciences equally, the differences in their later science achievement, course selection and career choice more likely reflects cultural bias imposed on youths through socialisation. Pieterse (2001) in Bonthuys and Albertyn (2007, p.27) captures the societal effect of gender role stereotyping on science and science education succinctly, when stating that:

> "Given the social pressures to conform to gendered stereotypes and their wide dissemination through the media, religious, educational and other social institutions, it is no wonder that people internalise stereotypical expectations (Pieterse, 2001)."

In placing science teachers in the context of the transference of gender perceptions from teachers to learners, Shaw (1995, p.6), in discussing the link between social settings like schools, the developing of social constructs like gender, and the social interaction that leads to the ultimate form of the construct, further points out that:

> "To social constructionism, the social setting itself is an evolving construction. When the members of a social setting develop external and shareable social constructs, they engage the setting in a cycle of development which is critical to determining its ultimate form."

Interaction involving learners and teachers in science classrooms is thus at the heart of the way in which the gendered nature of science is reproduced: it creates the challenges that face girls and results in the perceptions that science is for boys. A key aspect of this is the male-oriented environment of science classrooms. Murphy and Whitelegg's (2006, p.300) comment is significant when one looks at the male-oriented environment of science classrooms that girl learners find themselves in:

> "There is no quick fix to girls' participation in physics. Fundamental reconsideration of the contribution of physics to students' future lives is needed. …the problem is not the girls; rather, it is the teaching and learning of physics and the constraints that females experience in having to play a dual role in the public and private spheres without a concomitant shift for males."

Socialising agents like education and the media, reproduce the gendered nature and image of science. Together with these agents, Lorsbach and Tobin (1997, p.2) contend that there are other persons who are "part of our experiential world" who are important in contributing to learners' making meaning of experiences in their lives. This argument has implications for the science classroom situation where teaching strategies need to promote co-operative learning as a way of integrating others' opinions into learners' construction of their science knowledge. Lorsbach and Tobin (2007, p.2) conclude by maintaining that:

> "Using a constructivist perspective, teaching science becomes ... an active social process of making sense of experiences."

Lorsbach and Tobin (1997, p.3) also argue further that, in keeping with this constructivist epistemology, teachers should become more sensitive to the prior experiences that children use to construct their science knowledge. Thus, the messages that learners receive from society, like the discrepancy in the career opportunities for women as compared to men in science, together with the manner in which girls are socialised to accept the status quo regarding the place of women in society, all conspire to confirm, and by implication reproduce, the masculine image of science. It is within this masculine-oriented science environment that girls have to construct their own feminine identity with regard to science and where science has developed its male image as a result of its construction in a male-dominated society, as a male pursuit (Kelly, 1985). This image is supported by the prevalence of males in science careers and in the study of science; the 'packaging' of science as a pursuit for boys; the playing out of gender roles in science classrooms; and the innately masculine image of science. Whyte (1986) argues that the male-dominated image of science contributes to, confirms and reproduces the gendered, stereotypical expectations that, unless challenged, lead to role distortions. Gendered differences develop as society accepts these role distortions as the norm.

This thesis contends that the science teachers of the girls and boys participating in this research, as socialisation agents in classrooms where societal norms and values with regard to gender and science are transferred, continue to play a significant role in perpetuating the masculine image of science through the manner in which they transfer scientific knowledge to these learners via the curriculum. The science classroom, as one of the social settings in which the transfer of the male image of science takes place and where gender is constructed, is thus a significant locale for the reproduction of the status quo with regard to science and gender. The fact is that learners enter the schooling system with preconceived ideas of science and gender that have been developed at home and that are affirmed in society via various constructs. There is a wealth of evidence to support the contention that educators in schools, colleges and universities sustain and reproduce the masculine image of science (Eccles, 1989) and this will be presented in more detail in the next chapter. The pivotal role of educators in the transference of gender constructs in science and science education is aptly summed up by Harding's (1996, p.14) argument that:

> "At a crucial period in the development of modern science, gender constructs interacted to establish its dominant values and ways of working, placing science in a masculine straight-jacket."

2.4.3 Constructing gender identities in schools: the social context of the school and the curriculum

Haslanger's comment (2000, p.37) below on the manner in which some theorists use the term 'gender' provides an apt description of how the term is interpreted by learners and teachers; this interpretation forms the basis for their attitudes and perceptions, and ensuing behaviour, in the school environment:

> "Some theorists use the term 'gender' to refer to the subjective experience of sexed embodiment, or a broad psychological orientation to the world ("gender identity"); others to a set of attributes or ideals that function as norms for males and females ("masculinity" and "femininity"); others to a system of sexual symbolism; and still others to the traditional social roles of men and women."

This view of gender, that attaches social 'meaning' to physical features that distinguish males and females, forms the basis for the norms and values that our society holds for girls' socio-cultural interaction; these are then transferred to learners in school classrooms and playgrounds such that, where they would have liked to be regarded as "abstract independent individuals" (Gordon, 2006, p.2), they find that they cannot escape the gender-based perceptions and attitudes of other learners and teachers. Gordon further comments that girls:

> "...enter a 'transpositional' space that frequently reminds them of their gender." (2006, p.2)
> and
> "In school practices girls encounter gendered differentiation in the official, informal and physical school." (2006, p.2)

The learners participating in this research are treated as girls and boys with all the accompanying stereotyping and gender bias. The value added to the fact that they are girls or boys, influences attitudes to and perceptions of what they should do and how they should act, placing limitations on them in the formal spaces (like classrooms) in schools and the informal spaces (like school playgrounds). Thus, instead of classrooms' becoming 'gender blind', they become spaces where learners' gender determines what is expected. In addition to these perceptions of what it means to belong to a specific gender, the connection of physical bodily characteristics to gender is an important aspect of the construction of masculinities and femininities in schools (Paechter, 2006). Paechter, in a study that focused on the construction of gender in the social systems that children are part of, including the schooling system, refers to Descartes in connecting the 'mind and body' idea to the construction of gender and its implications for schooling. He uses this Cartesian understanding that identity is located in the mind and that the body is excluded from consideration of gender (Paechter, 2006) to place the construction of masculine and feminine identities in the school setting. Paechter (2006, p.125) goes further to state that:

> "The sex/gender distinction, at the very least, suggests that what one's body looks like or how it functions is independent of whether one considers oneself (and so should be accepted as) male or female. Gender becomes independent of the body, something that pertains only to the social, to the mind."

According to Paechter, the implications for this Cartesian 'binarism' in gender construction is that, since the main focus of schooling is on the mind and mental capacities, subjects that require mental dexterity, like mathematics and science, are more aligned to males than females. Paechter (2006, p.131) refers to the body and the way that it is adorned as indicating gender; whilst this approach is under scrutiny and has been described as "not being helpful", it validates the relevance of the physical aspects of gender in terms of body shape and the way that either gender is identified by the distinctively different clothes that are worn in most societies, as a determining factor in gender stereotyping:

> "The body as a dressed and decorated object is thus used by children, in school and out, as an indicator of gender and (therefore, in their constructions) of behaviour. Children can thus be seen to use their bodies to construct, express and demonstrate gendered identities."

In addition to labels that are ascribed to them based on physical appearance, our learners are entering gendered school playgrounds, where they encounter an environment that is already geared towards particular attitudes and perceptions regarding gender, construct their own perceptions of gender. Their teachers and peers have gendered opinions and subscribe to gender stereotypes. Coupled with their own constructions of gender, these prejudiced environments limit girl learners in particular with respect to areas like science and places them in a predicament where they aspire to flourish and progress but are limited by their own and others perceptions of and attitudes to gender. Our girls' and boys' academic lives and aspirations are thus 'boxed in' by their own perceptions of gender as well as a gendered society that spawned a gendered schooling system. Reay (2001, p.153), in research conducted with girls and boys, concludes that:

> "...girls and boys still learned many of the old lessons of gender relations which work against gender equity."

The formal delivery of the science curriculum in South African classrooms, also presents a setting, albeit more controlled, in which gender is constructed; as learners interact with each other and with teachers whilst engaging with the curriculum, they experience behaviour that expresses gendered norms and values. Learners' own constructions of gender will most likely be challenged and adjusted in classroom settings as they "negotiate a social gender identity" (Ivinson and Murphy, 2003, p.92) whilst coming up against peers' and teachers' views. Ivinson and Murphy (2003, p.92) go further in discussing learners' gender identity construction in classroom settings when, in alluding to masculine-gendered views, they argue that:

> "Hegemonic social representations of gender may be reinforced, challenged or transformed through classroom practice."

Another aspect of the curriculum and the manner of its delivery (in effect, the 'hidden curriculum') has contributed towards creating a gendered environment in schools that needs discussion. That is the masculinity and femininity that has been attached to certain subjects, also in South African schools. An extreme example is Physical Education: by the mere fact that it is still presented to boys and girls in separate groups, it confirms the gendered nature of the parts of the curriculum to its main clients, the learners. Home Economics, that in South Africa is titled Consumer Studies, has a gendered history and is still perceived as a 'girl's subject'. Paechter and Head (1996) pick up this debate in their research into the link between marginal subjects, Physical Education and Design and Technology, and learners' perceptions of their gender identity. The aim and purpose of Home Economics was to train girls to be good housewives. Whilst the subject, in South Africa, is now also offered to boys, it was previously formally limited to girls only. The curriculum, in these marginal subjects, confirmed and formalised gender differences in the way in which education was perceived and delivered. The gendered legacy of these two marginal subjects is evidence of the official manner in which gender identities were constructed and endorsed by society, using education as its agent, in formal institutions like schools using official curricula. With regard to teachers' role in this continued gender inflection in marginal subjects that form part of the school's curriculum, Paechter and Head (2003, p.28) conclude that:

> "In marginal areas, however, while teachers are often very clear about the way their subjects have become gendered, they remain unsupported in their struggles for greater equality and opportunity, both for themselves and for their students. Life in a marginal subject can be a constant fight against gendered stereotypes, one which is sufficiently supported by those outside."

Our teachers need to bear in mind that the curriculum, a vehicle for transferring society's norms and values to learners, is not transferred in a vacuum. It operates in the framework of the life worlds of learners and in the contexts of race and social class.

2.4.4 Gender intersecting with other forms of inequality

While education plays a power role in reflecting and reproducing normative gender roles and power inequalities, gender is never alone but always intersecting with other forms of power. Power inequalities in society render disparities in the participation rates between men and women as reflected in the 'women in science' debate more complex. These inequalities are located in the economic potential of communities and in their racial and class-based make-up, amongst other aspects. The girls and boys participating in this research are submerged in a community that reflects

a particular level in that power inequality nexus. Stanworth (1981, p.12) refers to the impact of this aspect in his comment that:

> "Explanations which purport to draw upon the "essential differences" between the sexes are no substitute for understanding the social construction of inequality and the point at which it can be undermined."

The above quote confirms that, if initiatives to bring about gender equity in science classrooms are to succeed, account must be taken of the way in which gender is socially constructed in terms of social variables with which it is interconnected (Rennie, 1998). However, as a social construction, gender cannot be singled out as the only reason for suggested differences in academic performance and perceptions of girls and boys. The context of the lives of the girls and boys participating in this research is beset by numerous social constructs and material conditions of difference and inequality. These differences and inequalities, evident in the biographical data of their lives, impact on their perceptions of science and science education. Within the 'gender in education' debate, the educational discourses that homogenise all girls and consider them as a single group with seemingly uniform characteristics, are constrictive and disregard the broader social inequalities that exist in societies.

In looking at gender equity one needs to bear in mind that, aside from the influence of gender on science and science education, other sociological and cultural categories like class, race, ethnicity, language, and lifestyle and religion also mediate their role in creating gendered imbalances in science classrooms. These categories also stem from genetics and further complicate investigation into the role of gender in science and science education. Gender thus intersects with race, ethnicity, class (Krockover and Shepardson, 1995) as well as religion, culture, language and access (Rennie, 1998) in the 'women in science' debate. In addressing gender equity in science teacher education, Rennie (1998) suggests four theoretical perspectives from which to view girls', and other minorities' disadvantage: the recognition that some learners are less well prepared than others to benefit from science education; the manner in which the science curriculum is delivered and assessed; the content of the science curriculum which is stereotyped with respect to gender; and the science curriculum's implication in producing and reproducing of gender inequality.

When commenting on the concept of an 'all-inclusive' science which takes account of race, ethnicity, class, religion and language, Howes (2000, p.396) points to an awareness, that "science has been used, socially, politically, and in education, to maintain racist categories and oppressive practices that support the status quo". In the context of the history of South African and particularly its education system, the learner cohort in this research typify the kinds of experiences that one would expect in a developing country emerging from colonialism and Apartheid with its race and class

divisions, the effects of which are still evident in the society. The impact of learners' gender feeds into this race and class culture and ensures that its effects are compounded.

The local socio-cultural circumstances of boys' and girls' lives are an important consideration when investigating their perceptions of gender with regard to science, as it interfaces with their schooling. These "cultural entanglements" that Archer and Yamashita (2003, p.129) mention in attempting to understand the "complex racial and diasporic influences" (Archer and Yamashita (2003, p.130) in boys' construction of their identities confirm the multifaceted nature of the issue. The phenomenon of globalisation and the migration of Third World peoples into First World communities brings this reflection on the matter into sharper focus; girls in these environments face the added challenges of social inequality and adapting to foreign environments, including language, in attempting to better their lives through education. South Africa is an example of this in that people from countries in Africa are migrating to the country, and into its education and economic systems, in search of better education and economic opportunities. They bring with them their own cultural practices and beliefs regarding gender and existing perceptions of science and science education that have to be negotiated in their 'new' country.

Teachers and learners are, to a certain extent, accomplices in maintaining gender disparity by conforming to socially accepted behaviour in this regard. The manner in which their race, class and ethnicity intercede in this gender disparity serves to exacerbate the imbalance. As pointed out earlier, this is especially so because of the demographic make-up of the learner cohort that participated in this research: they reside in an area with an homologous racial, economic and classed community where unemployment, the crime rate and substance abuse are high. The socio-economic, cultural context of schooling does have an impact on the perceptions of learners, also of science and science education, and their opportunities. Apple (1989) and Ogbu (1992) are of the opinion that learners who are socialised in a culture that regards schooling as important have a better chance of success at school and in school science. From a social constructivist perspective (Scantlebury, 1998), the socio-cultural context (Parker, Rennie and Fraser, 1996) in which science education is practiced exercises a powerful influence on the participation and performance of girls in science. In discussing the correlation between social variables and learners' assimilation of science knowledge from a social constructivist perspective, Scantlebury (1998, p.100) refers to Tobin's (1993) view that:

> "Social constructivism accepts that learners construct their own knowledge but that knowledge is developed and influenced by their social experiences and interactions."

The geographical and cultural contexts of learners' lives need to be considered when analysing girls' and boys' participation in science. Learners living in a rural setting in a Black African village with its specific culture could be expected to have a different geographic and cultural impact

on their science classroom experiences, from a gender point of view, than that of learners residing in the city, since socio-cultural norms and values differ. Even within cities, where neighbourhoods are 'divided' by social class 'boundaries' because of the economic capacity of parents, the science classroom experience could be expected to differ since learners come from homes that are resourced differently. Also, they have parents who have different educational, socio-economic and cultural backgrounds. Kahle and Meese (1994), Kreinberg and Lewis (1996), and Clair (1995) refer to this complexity when they point to individual, socio-cultural, family and educational variables that shape female science learners' images of themselves and others.

Socialisation and the home are regarded as key contexts responsible for the disenfranchisement of girls as science participants (Ndunda and Munby, 1991); the dynamics at play in these two areas result in girls' being sidelined in science education. The girls in this research grow up in homes with particular cultural values and are raised with the message that science is for boys as is evidenced by the reported opinions of their parents regarding the careers they want their children to aspire to. They thus enter the science classroom 'on the back foot'. Alton-Lee, Nuthall and Patrick (1993) refer to this when pointing out that, as a consequence of the socialisation process, discrepancies in the participation of girls as compared to boys in science result from girls' being micro-manipulated in society in three ways: by the socio-cultural process in society, by the classroom and by the science curriculum.

The influence of socio-cultural factors and the need for gender equity is widely discussed in the literature relating to the issue of the involvement of girls in science. Gender issues do not exist in isolation (Kreinberg and Lewis, 1996) and there are startling disparities amongst people in developing countries doing science education (Cobern, 1998). In this aspect of the 'gender in science' debate, Davis (1991) considers power an important social construct. In South Africa, the history of gender issues in science gains more importance when seen against the background of racial segregation, social engineering and the power relations stemming from the Apartheid policies of the past, as well as from socio-economic factors.

When examining gender equity in school science one cannot ignore the influence of gendered, stereotypical gender roles and the effect they have on participants in the educational process. Granstam and Frostfeldt (1990) and Rennie, Parker and Hildebrand (1991) point out that where schools had low levels of girls' involvement in science, two factors were at work: cultural values that don't promote equity, and limited resources which restricted opportunities. They caution, however, about the liberal use of statistics because of the need to contextualise cultural values.

It is clear that one needs to be circumspect when applying statistics about the reasons for the lack of girls' involvement in science gathered in Western countries onto Third World and developing

countries because of the difference in the socio-cultural context and its influence on education. In comparing patterns in science achievement on an international level, Keeves and Kotte (1996) note that the patterns observed in the differences between girls' and boys' performance were the effects of societal forces and educational practice. In this respect, the quality of science teachers and teaching strategies, the resources available in the education system and the soundness of the structures responsible for the delivery of education become an important context for the participation and performance of girls and boys in science.

2.5 Concluding remarks

The above framework highlights the issues that researchers are raising in the debate about the role of gender in science and science teaching. It forms part of the broader topic of the theories of science education and the contexts within which they are formulated. In this chapter I have shown that, since society constructs gender roles that need to be reflected on when considering their impact on girls' and boys' engagement with science, gender has a socio-cultural context. I have also indicated how parents and peers in socio-cultural settings like homes and school playgrounds, using language, continue to subscribe to gender stereotypes in framing the gendering of science. I have concurred with the view that science has a male image and have shown that this has been used as a focal point for feminists who contend that women have been marginalised in science, thereby drawing attention to the ideological and socio-political factors in the debate. The chapter also confirms the role that teachers and learners in science classrooms play in perpetuating the gendering of science and reveals the impact that the curriculum has on the phenomenon.

It is my opinion that social constructionism adequately describes how learners 'acquire' a science identity. There isn't one, all-inclusive theory of science education that fully encapsulates all the ways in which the gendered nature of science is 'learnt' at all levels in the education system. The dominant construction of gender and normative gender roles intercedes and mediates the development of learners' science identities and the manner in which their scientific knowledge grows. My focus in this thesis is on the social processes and influences through which learners develop their gendered notions of science and how science itself, in its current form, perpetuates this male image.

The way in which gender is interpreted in society leads to gender role expectations and creates gender stereotypes which play themselves out in aspects of society's functioning, like in education, specifically science education. The meaning that society attaches to the term 'gender' has differing implications for different communities and plays itself out in cultural settings. Whatever the setting, the different expectations shape the directions of the lives of girls and women and boys and men. It establishes expected behaviour patterns and appears to channel girls' aspirations into what

society expects. Gender stereotypes are the models that influence and guide learner behaviour and gender norms are regulatory mechanisms that set behaviour patterns. As a vehicle through which expected behaviour patterns are channeled, culture presents a powerful social construct. Through the norms and values of society, as ensconced in differing traditions, culture presents a vehicle for reproducing the gendered nature of science. Ceremonies and religious practices are permeated with and influence the perceptions of the role of women and girls in society and create different contexts within which the gender debate plays itself out.

In the social framework within which gender plays a role, the family is the core unit in society, the site where the child first encounters gender and in which gender role expectations are established. The clothes that the child is dressed in and the toys that are presented to it all conspire to create and develop the gender persona. Parents and siblings treat boys and girls differently and expect different reactions from boys and girls in certain settings.

The rocky relationship of science with gender and women in science in particular is an important focus of the struggle for gender equality. The masculine image that science has developed over the years, because of the significant role that men continue to play in its processes and procedures, whilst under pressure, continues. The progress that has been made in breaking down the masculine image of science is due, in no small part, to the struggle for gender equality that has made the 'women in science' debate a key part of the call for the greater and more equitable involvement of women in society generally. It is interesting to note that, in a recent development in the United Kingdom and Australia, there is a concern that boys are falling behind. The general consensus is that, because of the concerted focus on girls, they have progressed to the extent that their academic achievements in classrooms surpass those of boys (Reay, 2001). Boys' issues are being sidelined and there is a movement to refocus on boys (Skelton, 2002; Gordon, 2006). This has been perceived, especially amongst feminists, as a move by education systems to 'take their foot off the gas' with regard to gender equity issues for girls (Keddie, 2010; Reay, 2001). There is the added concern amongst feminists that 'minority group' girls, those who are discriminated against because of race and class, will be forgotten and fall further behind in the stakes for gender equity (Keddie, 2010).

The dual function of education presents challenges with regard to the masculine image of science. Whereas the fine balance between continuity and change has to be maintained, it appears that education is losing the battle in this area, since the masculine image of science persists. Whilst progress has been made with regard to the performance of girls in science, the challenge lies in changing perceptions about the masculine image of science; it is here that schooling is under-achieving. One of the challenges in this respect is the role that teachers play in reproducing the gendered image of science through their delivery of the curriculum and the influence of their own

'gender baggage' on the way that they teach and interact with learners regarding gender. The contribution of the schooling system in transforming the gender identities of learners with regard to science is inadequate also because learners enter the system with gender perceptions shaped at home, which are then rubber-stamped in the classroom. The masculine image of the science curriculum and the processes and procedures in the delivery of science lessons, compounded by the actions of teachers, don't help to change learners' constructions of their science identities. In short, the schooling system appears to be reproducing the status quo with regard to gender and science.

The social context of learners' lives, where issues like poverty, racism and other socio-cultural differences play themselves out in local environments, impact on their lives and influence their gender perceptions. A girl's gender, which already puts her at a disadvantage in some circumstances, is then further impacted by the effects of her poverty, other socio-cultural differences and ethnicity. All these conspire to limit her aspirations.

The gender inequalities inherent in the outcomes that the masculine image of science and science education has spawned through social practices and actions in social institutions persist, and society's response to them continues to be inadequate.

CHAPTER THREE
Gender, science and science education: findings from empirical studies

3.1 Introduction

Since the 1980s, there has been a proliferation of research and writings on gender and science education. The debate has been shaped and deepened by the views of feminist researchers and critical educationists. This chapter looks at gender in science and science education and aims to draw on the literature regarding the impact that gender has on science and science education in contemporary contexts. The goal of the chapter is to provide a critical review of the literature that illustrates the way in which gender impacts on society and how science and science education are gendered.

A specific field of research that focuses on science education has developed. This research is reviewed in the chapter, which outlines the foundations of the promotion of the masculine image and identity of science and how these affect the selection of science as a subject to be pursued in secondary schooling, especially by girls. The manner in which society has gendered science identities to give them a masculine image is discussed. The chapter provides an overview of research findings related to gender differences between boy and girl learners with regard to interest in, attitudes to and perceptions of science that have developed as a result of socio-cultural influences. A review of studies on the influence of the general school environment and the social dynamics of science classroom interaction on the gendering of science, are further elaborated on. The decisive role that teachers play in science education, and particularly the views on the gendering of science that they bring into science classrooms and how these influence the way in which they deliver the science curriculum, is unpacked.

An examination of the classroom context in which science teaching takes place is crucial to understanding the gender differences that are reproduced and re-entrenched in society and its formal institutions (like institutions of education). In this regard, the chapter gives an overview of the literature regarding co-educational and single-sex school types with reference to participation and performance in science. The influence of learner and teacher support resources, like textbooks generally and science textbooks specifically, that are used during science curriculum delivery, is later examined. The chapter also reviews literature on the gendering of science in the tertiary education sector.

Finally, research on the manner in which images relating to science and specifically scientists, are presented in the popular media and particularly in the electronic media, are also reviewed in the chapter.

3.2 Gender and science education research: overview

According to Fensham (2004), a focus on gender issues in the science curriculum and pedagogical practices arose during the 1980s, evident through work such as Allison Kelly's (1981) 'The Missing Half ' that highlighted and theorised the under-representation of girls in science and science education and the masculine image of science.

In her comment, subsequent to attending a National Association for Research in Science Teaching (NARST) symposium in Chicago 1997, Rennie (1998) noted that early research into the issue of the gendering of science focused on documenting and quantifying the disparities between girls' and boys' participation in science as well as the performance of girls in science as opposed to that of boys; identifying the barriers to girls' participation; and educators' strategies to compensate for the disparities in order to reduce the effects of the gendering. According to Rennie (1998), research then evolved into focusing on education and the way in which educators' social and cultural stereotypical views presented science and how this impacted on, in particular, girls' views of science. Part of this included a focus on classroom practice – encompassing the cultural and social character of learners as they experienced science and the resources that educators used in order to teach the subject. The research methodology also then shifted to focus on quality rather than simply on quantity (Rennie, 1998, p.960) with an emphasis on, for example, subjective learner experience:

> "Researchers recognized that they must attend to the participants' own construction of science and science learning, and that they must listen to girls and boys,...to learn about their lives and their experiences in science..."

Rennie's opinion points to where this particular research project is located – the investigation of the impact of gender on learners' subjective perceptions and expectations of science and science education.

The research into science and gender has evolved into looking at the manner in which science is used in society and in schools as a means of giving certain social groupings an advantage over others. In so doing, it gives credence to the feminist view that science reflects predominantly masculine views that marginalise women. However, Krockover and Shepardson (1995) also emphasise the need for race, ethnicity, class, and socio-cultural identities to be included in understanding participation in science.

Feminist views on science research have focused on science as a male-dominated, masculine domain. Sharon Kleinman (1998) mentioned that some people justified the disparities in participation and performance between men and women in science on the basis of women's perceived inferiority. Kleinman (1998) suggests that feminist scholarship's view of the ideology of science as a masculine domain is a political view that is growing in stature and is focused on improving the opportunities for

women to participate fully and on an equal footing in science and science education and also in society as a whole.

Gender issues in science education have assumed growing importance to researchers, policymakers and governments, especially in the Developing World. Tobin (1996) argues that it is important to consider issues of gender equity in science education in the context of the technological revolution in education and the potential that its effects will have on the 'gender equity in science' debate.

Different theoretical aspects of the gender bias in science have been focused on as researchers fleshed out the influences impacting on girls as they interacted with science and the causes of the under-representation of women in science. These influences are alluded to by Mitchell and Hoff (2006, p.10) in a study on whether hard work leads to success. The study investigated the perceptions of 121 Grade 10 and 11 (high school) science learners from a school outside Montreal in Canada, when they argue that:

> "...we cannot fully understand the under-representation of women in the sciences without understanding the forces that operate at various levels: societal, educational, familial and personal."

There has been a strong focus on the role of girls and women in society because of their historical marginalisation in economic and political spheres and because of attempts to bolster their interest, participation and success so as to bring about a better 'socio-economic, political' gender balance. This attention has also found expression in the participation of girls and women in science and science careers. Key issues that researchers have focused on and that will be elaborated on in this chapter include:

- The socialisation process of girls and boys, both in the home as girls interacted with family, as well as in broader society outside of the home. This process includes the effects of cultural and religious influences from society and more particularly from parents and other significant adults in girls' lives;
- Education, encompassing the curriculum and how it is delivered by educators; the textbooks and other learning resource materials which learners use; and the interaction between learners and educators in schools;
- The career prospects of girls in science and the manner in which these science careers have treated women;
- The influence of feminism on the 'women in science' debate;
- Gender equity and the role of policymakers and governments in dealing with the phenomenon of the disadvantaging of women in science;

– The media and the gendered manner in which science and scientists are portrayed.

A significant contribution to the research field involving girls and science was made by Brotman and Moore (2008) when they reviewed the literature, spanning a 12-year period from 1996 to 2008, on the topic. They developed four themes under which they categorised the literature on girls' engagement in science: "Equity and access; curriculum and pedagogy; the nature and culture of science; and identity" (Brotman and Moore, 2008). At the heart of these themes lie the multifaceted issues that bring to the fore questions of gender and science, issues mentioned in Brotman and Moore's (2008, p.995) review of studies in this regard:

> "Studies in this review clearly illustrate the complex and deep-rooted issues that underlie questions of gender and science. These underlying issues deal with intricate and varied individual identities, with societal inequities, and with long standing cultural ideas about what it means to be a female or a male, a woman or a man, a girl or a boy."

Aside from summarising the main foci of the literature, Brotman and Moore (2008), in conclusion, also identified areas where gaps existed that could be focused on by future researchers. These areas include: "gender inequities across different contexts in the classroom of the present day, contextual factors both inside and outside the classroom, the experiences of girls who *do* enjoy and engage in the *physical* sciences, intervention at the elementary level, informal or extracurricular science education experiences, teacher education and professional development programmes, gender-inclusive curricula, issues of bias and sexism and the nature and culture of science" (Brotman and Moore, 2008, p.993). It is hoped that this research will make some contribution towards closing those gaps.

3.3 Gendered responses to science amongst learners

This section deals with the manner in which learners have responded to science as a consequence of the manner in which socio-cultural influences have impacted them regarding its gendered nature. In this regard, socio-cultural influences encourage the development of science identities based on gender stereotypes. These gender stereotypes are partly responsible for the differences in learners' interest in, attitudes to and perceptions of science.

3.3.1 Developing a science identity

A key area of research in science education and gender has been the way in which science identities are gendered. Learners' internalisation of social, cultural and personal experiences provides a context for the development of an identity with regard to science and science education. In their study, involving 36 children in Grades 1 to 3 from a public school in the American Midwest, that

investigated the development of science identities, Tucker-Raymond et al. (2007, p.560) comment that:

> "Developing scientific identities is important as it allows for participation in scientific activities, developing opportunities for ways of living."

According to Tucker-Raymond et al. (2007), 'designated' identities, such as that ascribed to scientists, are relayed to learners through social interaction like personal experiences that learners have inside and outside of the school environment, as well as from experiences resulting from interaction with family members, various media sources and other daily activities. Learners assimilate these designated science identities into their own and so construct a version of what science and scientists are about.

Brickhouse et al.'s (2000, p.441) comment that a view of science as a "culturally mediated way of thinking and knowing", and that learners' engagement with school science has to do with the kind of person that they are, places a focus on the development of science identities. A study that was conducted in a school on the American East Coast, of four middle school African American girls' interaction with science, was described within the context of their social lives and personal experiences and, with regard to the development of a science identities, Brickhouse et al. (2000, p.442) comment that, if learners are to learn science, they need to develop identities that are compatible with science, concluding that:

> "Student identities, as well as teacher responses to these identities, are shaped by gender, race, and class relations, among other factors. The influences of these factors are complex but nonetheless powerful."

Brickhouse et al. found that the context of girls' lives is an important factor in the development, or not, of their science identity, and that the pedagogy used in science classrooms does not always allow for a wide variety of ways for girls to engage with science. This leads to girls' being categorised into predictable science stereotypes. Because science is an academic as well as a practical subject, girls who lack academic skills but are interested in the practical aspects of science could not progress in the types of structures existing in some education systems. Brickhouse et al. (2000) also found that the curriculum is not always flexible or diverse enough to accommodate the kinds of engagements that suited some girls' identities. They question whether the differences between girls and boys are not being exaggerated at the expense of investigating their diversity and how this might affect their engagement with science.

The science curriculum, as the medium through which science is presented to learners, also plays a part in the development of science identities. To illustrate the contribution of the science curriculum in the development of science identity, Hughes (2001, p.287) interviewed three mixed-

gender pairs of students in order to relate the "discourses and practices of science education to the production of individual science identities" and found that science students' subject positions interact with positions of gender, class and ethnicity. Hughes (2001) added a new dimension to the debate on the gendering of science by reflecting that student subjectivities, however complex and shifting, need to be recognised and considered when contemplating how science identities are cultivated. Aschbacher, Li and Roth (2010), in exploring the link between the development of learner science identities and their leaving the science 'pipeline' at the end of the secondary education phase, found that there were 'microclimates' in which children grow up that influence the development of learner science identities. These 'microclimates' include influences that emanate from the school science environment, 'science advocates' who interact with learners, and the opportunities that learners get to engage with science in society. Hanover and Kessels (2004) talk of learners 'matching' their identities with the images that they have of a 'prototype' of the science and mathematics curriculum. They refer to the high incompatibility that exists between learners' self-image and the image that they have of subjects like science and mathematics (Hanover and Kessels, 2004). The gendered manner in which the science curriculum has been constructed and its exclusivity is regarded by Hughes (2001) as symbolic, since it presents Physical Science as masculine and Biology as feminine; this symbolism reproduces and legitimises gender divisions, undermining the development of a science identity for girls in particular.

3.3.2 Gender-related differences in attitudes to and interest in science

Whereas attitudes to science indicate a manner of thinking about science, an interest in science shows an amount of curiosity towards science that has the potential to lead to an active engagement with it.

Primary school years appear to be a significant period with regard to the cultivating of attitudes towards science. Omerod and Duckwerth (1975) are of the opinion that attitudes to science are formed during these primary school years. Kelly (1985) and Kahle and Lakes (1983) state that although learners' experiences of science differ as they enter the primary school – with boys using science instruments more, reading more science and interacting with science educators more often – they enter with an equal interest in science. There appears to be a dearth of research on the attitudes towards science of Grades 1 to 5 in the elementary school. However, during this period, visual images and language text in books targeted at this age group appear to be influencing them with regard to gender role stereotyping. Notwithstanding, a study was undertaken by Andre et al. (1999) which described, developmentally, learners' from Grades K to 6 and their parent's attitudes to

and beliefs about science and other subject matters. In this study to determine cultural stereotypes and self-perceived competencies, Andre (1999) established that:

- Boys perceived their Physical Science competence higher than did girls;
- Parents perceived science as more important for older children and for boys;
- Parents expected higher performance in science from boys than from girls;
- Learners regarded jobs in science as more male-dominated.

The findings suggest that attitudinal gender differences related to Physical Science begin to develop by the earliest elementary school years (Andre, 1999).

The next significant period of the institutionalised 'cultivation' of attitudes to and development of perceptions of science appears to be during Grades 7 to 8. Riis (in Husen and Keeves, 1991, p.114) points out that there is a change in girls' attitudes towards science in Grades 7 and 8, with the most striking change occurring in Grade 7 (girls 13 to 14 years old), when the majority of girls "believe in the benevolent potentials of science". The girls hold the expectation that science and technology have the potential to find remedies to counterbalance their own harmful effects. Also, in Argentina, the survey of the National Program to Promote Equity for Women (PRIOM) found that at the end of elementary school, girls achieved the same grades as boys in mathematics and science but that this performance dropped considerably at the end of the first cycle of the secondary school (Clair, 1995).

In a study undertaken to elicit learners' perceptions of science and scientists, Jones et al. (2000) found significant gender differences in science experiences, attitudes to, and perceptions of science courses and careers. More specifically, they found that more females than males reported that science was difficult to understand. Jones et al.'s (2000) view that girls' attitude to science wanes as they proceed from elementary to middle school concurs with that of Riis (Husen and Keeves, 1991).

Studies have pointed out that girls and boys experience school differently (Sadker and Sadker, 1994). A strand of feminism, difference feminism, contends that girls demonstrate traits that are peculiar to their gender (Howes, 1998). In affirming gender differences in interest in science, difference feminism argues that girls would, by implication, be interested in science that "connects to human bodies, children, and traditional women's responsibilities" (Howes, 1998, p.877). This resonates with research that indicates there are differences between boys and girls with regard to attitudes to, experience of, interest in and perceptions of science, and that, whilst girls are showing a greater interest in life sciences like Biology than in the physical sciences, boy learners show a greater interest in Physical Science (Joyce and Farenga, 1999; Miller et al, 2006).

Learners' interest in, attitudes to and perceptions of science and scientists do not occur in a vacuum; they evolve within the context of their socio-cultural development, social context and schooling. In their study involving a sample of Grade 6 learners from the United States of America USA), Jones et al. (2000) reveal that significantly more females than males indicated that they found science difficult to understand; boys had more extracurricular experiences in physical sciences; girls had more extracurricular experiences in the biological sciences; boys had more interest in the physical sciences and girls had more interest in the biological sciences. The findings also suggest that these differences in 'science content-related interests' may begin early. Furthermore, with a lack of extracurricular science experiences through puberty, girls and boys entering middle school encounter their peers' stereotyped sex-role beliefs, advancing the potential for the widening of the gender gap with regard to perceptions of science and scientists. This view bears out Baker and Leary's (1995) belief in the connection between choosing science and learners' interpersonal relationships. Similar conclusions were reached by Miller et al. (2006) in a study, involving Grade 10 to Grade 12 high school learners from a small southern city in the USA, that investigated their attitudes to science classes, perceptions of science and scientists and views about majoring in science, namely, that:

- girls were more interested in the people-oriented aspects of their science major
- biology was the one exception to girls' low interest in science
- girls selected a science major because they needed it to enter a health profession and
- girls found science uninteresting and their perception of a science lifestyle unattractive.

The theme of research findings, that high school girls prefer Biology over Physical Science as a subject, also emerges in the exploration by Christidou (2006) of the science-related interests and out-of-school science experiences of Grade 9 Greek learners. The study confirmed that girls were more interested in sciences like biology, health and fitness whereas boys were more interested in physical science and technology. This finding of the difference in the science interests of girls and boys persists in research. It points, rather, to a difference of interests within science, as in the nature of the science, rather than to an interest, or not, in science as such. In their research to establish the gender gap in science interests and how it changes as learners progress through grades, Baram-Tsabari and Yarden found that:

> "...a difference between boys' and girls' science interest did not exist during early childhood, but increased over 20-fold by the end of high school. Furthermore, the gap widened in a stereotypical manner, with girls being increasingly interested in biology and boys more interested in physics and technology."
> (Baram-Tsabari and Yarden, 2010, no page numbers, published online)

This links up with and confirms Braund and Driver's (2005) finding, in their research exploring learners' perceptions and experiences of science practical work, that learners' interest in science, on entering the secondary education phase, is high.

A study undertaken by DeBacker and Nelson (2000) examined the differences in motivation to study science, class type (biological science versus physical science) and ability levels of Grades 10 to 12 high school learners; the researchers found that despite girls having lower scores than boys on stereotyped views of science, girls reported lower perceived ability in science than boys. In other words, it appears that whilst girls don't think that they are as good at science as boys, they believe less strongly that science is stereotyped in favour of boys. DeBacker and Nelson (2000) ascribed the phenomenon to the possible influence, on a less conscious level, of cultural stereotypes or as just one symptom of a general lack of confidence that girls are reported to experience during adolescent years. This resonates with the findings of Miller, Blessing and Schwartz (2006) who investigated how gender mediated learner views of science: that the 'people-oriented' aspects of the science, the career pathways that the science offered and the differences within the science were the levers that swayed girls' views toward a particular perspective.

In an attempt to establish whether Year 7 South Australian primary school learners' attitudes toward science have changed over time, Dawson, twenty years later, repeated a similar collaborative study to one he undertook in 1980 (Dawson, 2000); he found that whilst there have been some changes in learner interest in science topics, boys' interest in physical science had strengthened considerably whereas girls' appears to have remained constant. This indicates an actual accentuation of the differences observed in the 1980 study. The lack of change in girl learners' interest in science over the 17-year period from 1980 to 1997 as indicated in Dawson's study is all the more noteworthy when he states that this lack of change occurred despite interventions. Its significance is further substantiated by similar results obtained after a similar study by Weinburgh indicated little change over the period from 1970 to 1991 (Dawson, 2000). Dawson (2000) cautions, though, that any changes in learner interest towards science cannot be subscribed to the influence of schooling alone and alludes to a recognition of the effects of the curriculum, teacher behaviour, the interaction between learners and teachers and the influence of the 'outside world' on learner interest in science.

Attempts have been made to establish the reasons for the declining interest in science from elementary to high school amongst girls in particular. In one such attempt, Osborne and Collins (2001), in their study conducted with 144 16-year-old learners from London, Leeds and Birmingham, exposed an apparent disparity in the learners' view of the relevance of science as presented in formal science lessons presented in laboratories or classrooms as compared to the science they experienced in everyday life – learners appeared to differentiate between 'science-in-school' and 'science-in-

society'. Girl learners' interest in science specifically, wanes from elementary school, through middle school to high school, where their disinterest appears to be substantial (Miller et al., 2006; George, 2006). In considering the reasons for girls' apparent escalating loss of interest and motivation in science as they proceed through the primary school and in the early phases of high school, McGinnis et al. (1997) express the interesting point that in the elementary or primary school and in high school, most of the science educators are women. The gender of the science teacher as a role model for science apparently influences the way that girls and boys view science.

Researchers have found that learners' interest in science in the classroom is affected by the emotional and social 'baggage' that they bring with them from the culture that they had been raised in. This is the basis for Carlone's (2004) examination, in an upper middle class school in North Carolina, of the manner in which the science curriculum was being presented as it pertained to learner interest in science. In an attempt to counter 'prototypical' science education's alienation of girls in science, Carlone (2004) used Active Physics, a reform-based manner of presenting the physics curriculum, to examine more deeply girls' participation and interest in science and how they developed science identities. What Carlone (2004) exposed was an aspect of what other researchers (Jones et al, 2000; Baker and Leary, 1995) had encountered – that learners' perceptions of, interest in and attitudes to science in science education have, as a context, experiences in their social and cultural lives beyond the science classroom, and that the meanings of science are culturally produced. When girl learners were requested to participate in the Active Physics manner of presenting the science curriculum, they refused to go along with meanings of science which threatened their status as good science learners, and were:

> "mostly concerned with accessing and maintaining a good student identity (rather than connecting to science in any meaningful way)." (Carlone, 2004, p.392).

The girls in Carlone's (2004) ethnographic study wanted access to a further field of study, where the current science course is a prerequisite condition, and did not want to threaten that future goal – they were less interested in being empowered about science. This adds to the complex nature of attempts to create a gender-fair science and science classroom. In responding to the gendering of science, science teachers face an uphill struggle in classrooms, to counter the influence of socialisation and culture with regard to science and its place in society and in learners' lives. In examining participation and achievement in school science, Zohar and Sela (2003) explored the gender issues at play in science classrooms in Israel and found that the lack of teaching for understanding and excessive competitiveness in science classrooms adversely affected girls. The view that girls needed to understand the issues in science as a way of connecting them to their life

experiences (Zohar and Sela, 2003) correlates with previously stated research findings (Jones et al., 2000) of girls' need for connectivity between science and their socio-cultural experiences.

The ubiquitous science class project, which teachers worldwide use as a curriculum delivery and evaluation tool, has been analysed for the role it plays in the gendering of science. Adamson et al. (1998) examined the onset of this gender differentiation by exploring Grades 1 to 6 learners' involvement in a science project fair. In determining that boys choose physics projects compared to girls who choose biological and social science projects, Adamson et al. (1998) established that the divergence in science interests begins quite early in childhood development. It would seem that social and cultural influences on children about science and science education continue to be nurtured as learners enters formal schooling. By late adolescence, when learners are in high school, gendered differences in attitudes to, interest in and perceptions of science appear to have crystallised to such an extent that Adamson et al. (1998, p.855) contend that the fact that "many fewer women pursue physical science careers may be viewed as cultural confirmation for the social construction that physical science is masculine". Feminist science and teacher educators from teacher colleges and university teacher education departments in the USA, Richmond et al. (1998), developed assignments to help their students feel comfortable with science and to empower them to engage in gender-sensitive scientific investigation. In their conclusion to the study of assignments, Richmond et al (1998, p.916) suggest to their students that to teach effectively, so as to attract greater learner interest in science, they should recognise the factors and limitations that have created the current, gendered shape and scope of science and understand how to reshape the factors so that they invite multiple perspectives and diverse groups of practitioners.

3.3.3 The academic pursuit of science studies: learner subject choices

There are factors that influence girls' selection of science as an academic field to pursue when they enter the FET Phase. From a Longitudinal Study of American Youth (LSAY) that began in 1987 and sought to track middle and high school learners' attitudes and achievement in mathematics and science over a period of time, George (2006) selected students for a study and, in a cross-domain analysis, examined attitudes towards science. George (2006, p.571) states that "one of the key factors in learning science is students' attitudes" and the results of the study show that:

> "...the overall trend for students' attitudes about the utility of science is positive, however, attitudes towards science decline over the middle school and high school years."

Learner perceptions of science and science education influence whether they will select science subjects as they progress from the primary and junior secondary phases of the GET on to the senior secondary FET Phase. George's (2006) findings point towards the need to improve learners'

science experience in the primary school years and into the beginning of the high school years in order to consolidate learner science knowledge and interest. Gendered differences in subject choice patterns are evident when junior high school learners have to make subject choices. Eccles (1989) points out that these differences become more pronounced as learners proceed through high school and persist in boys' and girls' reactions to gender role expectations.

The factors that impact learners' subject choices, especially their choice of science, was also the focus of Van Langen et al.'s (2006) study involving Dutch pre-university pupils who needed to select subjects for further study: the study exposed inequality of educational opportunity when learners had to make subject choices. Van Langen et al. (2006) used data from a large-scale national cohort of learners in the Netherlands that contained information on pre-university learners, their families and their schools. Their research examined the proposition that the provision of equal educational opportunities is threatened when groups of learners of similar academic ability, but from different social backgrounds, differ in their choice of subjects. Van Langen et al. (2006) stressed the importance of viewing learner subject choice as a chronological process that progresses differently for boys than for girls and established that, with otherwise equal capacities and achievement, girls' choice of science as a field of study in the secondary school phase is influenced by their family background (parental level of education, ethnic background) while boys' choices are not. They also established that the number of science and mathematics subjects chosen can be viewed as an indicator of school success. Van Langen et al.'s (2006) research findings showed that boys are more 'science-oriented' by the time they reach secondary education. Their study contains similarities with the Apartheid context of South African schools in that it reveals that the social class of girls, as determined by the level of education of their parents, positively influences their selection of science subjects. Their research lead them to state that:

> "Despite international reports of educational success for girls, very little has in fact changed over the past few decades with respect to their science and mathematics subject choice." (Van Langen et al., 2006, p.88)

There is no single factor that, along with gender, has a decisive effect on girls' choice of science as a career of choice. Interaction in science classrooms alone does not impact on girls' choice of science as a field of study to be pursued in the secondary and post-secondary school period. Girls' involvement in informal science education programmes plays a role in determining their educational and career choices with regard to science (Fadigan and Hammrich, 2004). In an American longitudinal case study to describe the educational trajectories of learners, conducted with academically talented, urban high school girls from single-parent, low-income homes located in mostly minority communities and who had an interest in science, the learners were offered

involvement in an informal natural science enrichment programme called WINS (Women in Natural Sciences Program). It was found that the majority of participants perceived having staff to talk to, learning job skills and being able to go safely to the museum, as influencing their educational and career decisions (Fadigan and Hammrich, 2004). It is clear that being taught by 'gender-aware' science teachers, practical involvement in science programmes that familiarise girls with the pursuit of science, and regular contact with science institutions are risk factors that play a role in getting girls 'across the great divide' that is the lack of their involvement in science education and science careers. Aforementioned are among the factors that place the equal participation of girls as compared to boys in science education and science careers at risk and are discussed in this thesis. These factors compound the fact that learners are girls and, with race and low socio-economic status playing a role, raise the bar for their selection of physical sciences at secondary school level and eventual entry into careers in the science field even higher than it would have been if they were boys. These factors can be mediated by presenting learners with more opportunities to explore their options and by science educators' presenting the science field in a new light which allows girls especially the duality of both studying science and helping others (Fadigan and Hammrich, 2004).

Questions about girls' motivation for their subject choices at secondary school level were raised in a session at the European Commission's Gender and Research Conference held in Brussels in November 2001, titled 'Reaching out to schools and society at large'. Participants focused on the relationship between education, socialisation and gender (2002). The session asked whether girls' choices were influenced by socialisation and pointed out that the need for understanding girl learners' choices required taking a closer look at their attitudes towards science. Baker and Leary (1995) concluded that girls are influenced to choose science as a field of study by their perceptions of interpersonal relationships, like their relationships with loved ones, and that these extracurricular experiences resulted in girls' having positive or negative attitudes to science. The study revealed more specifically that girls' motivation to choose science was also influenced by the possibility of their friends not supporting such a career choice (Baker and Leary, 1995). One of the more significant junctures in the 'leaky pipeline' that makes up the decreasing numbers of learners entering science faculties at tertiary level is the selection of physical sciences at the entry point to secondary education. Ivie and Ray (2005, p.21) agree with this view and are of the opinion that:

> "In fact, the leak in the pipeline for physics seems to occur at one point only, and that is between taking physics in high school and earning a bachelor's degree in Physics."

3.4 The school environment

The school environment is the primary site where perceptions of, attitudes to and interest in science are reproduced and impacted on. In this respect, this section looks at gender and schooling, the manner in which schooling needs to respond to changing social trends like globalisation, and the apparent dichotomy of the goals of schooling of both transmitting current social norms and values and yet preparing learners for a changing world. The section reviews the literature on different types of gender-based schools and analyses the literature that examines the manner in which interaction in science classrooms influences the gendered nature and image of science. In this regard, the influence of the science curriculum and the resources like textbooks that are used to deliver it, are reviewed. The impact of science teachers, interaction in science classrooms, the science curriculum and science textbooks all conspire and influence the choices that learners make with regard to continued academic engagement with formal science and literature in this regard is also reviewed here.

3.4.1 Gender and schooling

Fast-paced economic development, facilitated by globalisation and reinforced by rapid technological innovation, especially in First World countries, is leading to changing social behaviour patterns with regard to the gendered division of labour. As these changes filter into the workplace, they affect education, cascade into schools and have an impact on interaction in classrooms and the delivery of the curriculum.

Schools are at the centre of and mediate this rapidly changing, modern society. Whilst the role of gender in education remains significant, there are 'new' concerns, as pointed out by Arnot (2000, p.293) in a research paper highlighting the challenges that schools in the future may face, such that:

> "Traditional gender identities are changing and schools may have to respond to the gap between the educational success of young women and the discrimination they face on the labour market."

As argued in the previous chapter, viewed from a socially critical perspective, gender is the area where social variables like ethnicity, class and race conflate in education and therefore it cannot be viewed in isolation. A child's gender, then, has everything to do with the way that she or he is taught to fit into society's social patterns, norms and values. Formal education is one of the prime sites where this social 'schooling' in gender role expectations takes place. Schools have become very important sites where society's norms and values are transferred through social interaction in classrooms, through the curriculum, and on playgrounds. They are tasked with a dual function:

- maintaining the social order through the transmission of knowledge, and

- preparing learners for a changing world and society.

This apparent dichotomy in the goals of education presents challenges to teachers, with regard to gender specifically, to break away from the manner in which education is currently 'done' and to prepare learners for a society in which there is gender equity. In commenting on schools facing this dichotomy, Arnot (2000) invokes feminist educational theorists in stating that the status quo in school education with regard to girls is gendered and oppressive to women and prevents them from gaining access to power – that, whilst social behaviour patterns are changing, schools, through the delivery of the curriculum, encourage learners to maintain the basis of the moral order. A measure of gender equity has been achieved with the presence of a compulsory curriculum that ensures that girls receive the same curriculum content that boys do, but Arnot (2000) still feels that there is a need for classroom instruction to become more personalised and reflexive for girls, since they experience the transmission of the curriculum in a more personalised manner. Accommodating girls by adjusting science classroom instruction so that it becomes more personalised could possibly spark a shift in the gender climates of classes as boys become sensitive to educators' making science lessons more 'girl-friendly'. In referring to a possible shifting gender climate as a consequence of more girl-friendly science lessons, Arnot (2000, p.298) is concerned that, in their reaction to the shift, boys may become more violent in schools, "celebrate hyper-masculine identities" and distance themselves from femininity. Arnot (2000) is thus concerned that boys would overreact to the feminising of science lessons – which stereotyping taught them was 'their' domain – in order to re-establish and reaffirm the gender role stereotype and restore their maleness and dominance in other ways by, for example, becoming more violent or exhibiting more 'macho'-type behaviour.

As the already complex issue of gender becomes more intertwined with other social variables, learners and teachers, in executing gender equity policies, will need to be careful not to step on ethnic, class, race or religious sensibilities. This is particularly pertinent in South Africa, where gender and racial equity policies have the added challenge of undoing the effects that Apartheid has had on the social fabric of the country, and particularly the division of labour.

3.4.2 School type: co-educational versus single-sex

A school type comparison between co-educational schools (which make provision for girls as well as boys) and single-sex schools regarding attitudes to, interest in and perceptions of science entertains the enticing possibility that, were one to separate the sexes, there might be a leveling out of the gender-generated learner differences in science. In one of a limited number of studies evaluating gendered attitudes towards science according to school type, Dhindsa and Chung (2003) undertook a study amongst Form 3 14-year-old Bruneian learners, in which they compared co-

educational and single-sex school learners' attitudes to and achievement in science. Whilst Dhindsa and Chung (2003) caution that other learning factors need to be considered as contributing factors in the evaluation of gendered attitude towards science: they point out that while results from other similar studies in Brunei show only a slight deviation, overseas studies show no significant sex differences, but the results of their survey did show that in single-sex schools, girls had a more positive attitude towards science than that of boys. They also found that girls and boys in single-sex schools had a marginally more positive attitude towards science than boys and girls in co-educational schools. Parker and Rennie (2002, p.881) in their study that was part of a Single-Sex Education Pilot Project (SSEPP) at ten high schools in Western Australia, focused on the differences in the effectiveness of gender-inclusive teaching strategies when looking at single-sex schooling and found that what needed to be considered was:

> "...the nature of the instructional environment for both boys and girls, together with appropriate support for the teachers involved..."

In single-sex science classes, teachers needed special preparation that considered the sex of the learners when teaching them. School management needed to provide teachers with the support to enable them to derive maximum benefit from the exercise. Despite Parker and Rennie's (2002) view, that single-sex classrooms provided the ideal environment to teach gender-inclusive science, they commented that the attainment of equality in the participation rates of girls and boys in science by utilising this strategy remained elusive.

In a study on single-sex schooling that was part of a National Child Development Study (NCDS) conducted in England and Wales, and that focused on Mathematics, Science and English, and examined "the link between gender, school context and academic self-concept", Sullivan (2009, p.293) cautions that, whilst single-sex schooling "promoted a gender atypical self-concept", other factors such as parental social class and education levels play a role. The study concluded that conclusions on single-sex schooling cannot necessarily be drawn from research on single-sex schooling.

The caution that researchers advise in attempts to establish a correlation between improved girl learners' participation in science and single-sex classrooms is echoed by Friend (2006, p.1), who reached the conclusion in a study on same-gender grouping in Grade 8 science classrooms that:

> "...same-gender grouping did not produce significant differences in student science academic achievement and same-gender classes did not create a more positive classroom climate."

Like Sullivan (2009), Friend (2006) also suggests that factors outside of single-sex science classes like the nature of students and their families and institutional factors could possibly influence enhanced performance in science.

School type, in the form of single-sex schooling, does not necessarily improve the participation rates of girls in science and appears to have a mixed effect on the gendered attitude towards science amongst learners. In considering the manner in which the learning environment is semi-structured, Spellman and Oliver (2001) established a correlation between school organisational structures, in the form of extended time for science and learning outcomes, when they found that girl learners felt more positive about science when the period time was extended, and that this might be more in line with the way in which girl learners learn.

3.4.3 The dynamics in science classrooms

The science classroom is the site where gender issues in science converge: learners with diverse socio-economic and cultural backgrounds that influence their perceptions of science and science education are in the same space as their peers; teachers who have their own perceptions of gender, science and science education 'share' the same space with learners; the classroom itself has science resources indicative of the economic potential of the community; and the curriculum with its potential for gender bias is delivered to the learners. Learners and teachers enter the classroom with stereotypical perceptions of science and science education and experience the science curriculum via gendered learning support materials. Teachers facilitate the learning process through the interaction that takes place in science classrooms and have a major effect on learners' acquiring a gendered or balanced perception of science and science education. However, it is widely acknowledged that science has a masculine image and this has an effect in science classrooms, prompting attempts to bring about gender equity.

Research on gender equity in science has revealed that in high school science classrooms there is a discrepancy in the participation and performance rates between girls and boys. Johnston and Dunne (1996) indicate that educators, researchers and policymakers have become increasingly aware of the differences in participation levels of girls and boys in science at school. Furthermore, Tobin (1996, p.122) suggests that "the majority of females do not participate to the same extent as males and are not offered the same level of opportunities to learn". This view is reiterated by Fensham (2004, p.177), who points out that girls are participating less than boys in school science and consequently females are under-represented in most countries in professional roles: Fensham goes on to state that "science education is disproportionately servicing the two sexes, and hence there is a gender issue in science education". In a study that investigated girls' perceptions about assessment and the effect that it had on their interest or disinterest in science, Mitchell and Hoff (2006, p.2) in their study in Canada point out that:

> "The answer to why fewer girls pursue science, therefore, does not seem to lie in underachievement. Nor does the answer appear to lie in lack of access to science instruction."

Mitchell and Hoff (2006) are of the opinion that the interpersonal interaction that is taking place in science classrooms, especially between teachers and girls, holds the key to understanding why girls are not continuing to pursue science careers, and that the question of the under-representation of girls in science must include a closer look into the more subtle aspects of classroom climate which they labeled as 'chilly' for girls.

The learning environment influences girls' decision-making about whether they will pursue a science career. During communication in science classrooms, educators play a pivotal role in influencing the learners' perceptions of science and the subsequent disparity in the participation and performance of girls in science. Davis (1991) views the interpersonal relations in teaching and learning as a feature of the 'gender–power' nexus as it impacts learners' ability to construct knowledge. In learners' interaction with educators, the educator's sense of gender, which is constructed early in life by society, impacts on this interaction in science classrooms (Scantlebury, 1995).

Science teachers can make a difference in girls' gendered perceptions of science by their pedagogy and the strategies they use with respect to the resources at their disposal in science classrooms. In this respect, Head and Ramsden (1990) bear out Spears' observation regarding the teacher's expectation of girls' performance in science, with the argument that 'girl-friendly' science lessons broaden the appeal of science to girls. Teachers expect girls not to select science for further study and where they do, they expect them to underperform compared to boys. Their teaching style, knowingly or unknowingly, tends to promote science as a male-oriented pursuit. This substantiates the feminist viewpoint of changing the way in which science is taught and presenting scientific knowledge to learners such that it has a less hegemonic, male image. Kelly's (1986) call is for less gendered science to counter the effects of the manner in which science has been constructed and portrayed by society as a male-dominated pursuit. In expounding on the feminist viewpoint of how the current nature of science can be made more 'girl-friendly', Richmond et al. (1998, p.916) list the aspects of a science that is more in touch with the lives of women and girls: they contend that this scientific practice should:

> "...recognize the factors that have created its shape and scope, as well as its limitations...be reshaped so that it invites in multiple perspectives and diverse groups of practitioners...reshape it along with one's students...become empowered to critique, ...and go on to design their own ways of engaging in scientific investigation."

Alton-Lee, Nuthall and Patrick (1993) allude to the hidden agenda of male dominance in science education when including the teacher's management of the classroom as a strand in the

micro-manipulation of learners on an interpersonal level. This micro-manipulation has the effect of perhaps reflexively aiding the disparity in girls' interest in and perceptions of science. Clair (1995) argue that there is little investigation of the hidden agenda of the perpetuation of male dominance in science classrooms. Loudet-Vedir and Mosconi (cited in Clair, 1995) feel that this agenda is encouraged by educators interacting, albeit instinctively, more with boys than with girls in science classrooms. The school is permeated by an environment that reproduces unequal relationships between girls and boys in science classrooms; therefore Clair (1995) feels that there is a need to analyse concrete classroom situations.

This is aptly demonstrated in a study conducted by Ivinson and Murphy (2003) who came to the conclusion that teachers projected social representations of gender on boy and girl learners and then onto high and low achieving boys differently. Further important theoretical work derives from critical men's studies. There is widespread agreement that teachers, especially male teachers, play an important role in the development of hegemonic masculinities that prevail in schools (Skelton, 2002). Skelton (2002, p.24) sums up the issue when stating that:

> "...the attributes and practices of the male teachers contributed towards a mode of dominant masculinity which mobilized around a sharing of masculine 'values' in this case a sense of 'team spirit' fuelled by the use of humor."

The teacher's behaviour in the science classroom has consequences for gender equity and girls' perception of science in science classrooms. A number of issues that hamper and inhibit the greater participation of girls in science have been identified through research into interaction in science classrooms:

- Teachers display unequally greater interaction with boys compared to girls in a science classroom – the inequality was clearer in classes taught by women teachers (Clair, 1995; Baker, 1987; Mitchell and Hoff, 2006). This kind of teacher action affirms the 'science is for males' gender stereotype in science classrooms and increases the hurdles that girls contend with regarding their engagement with science.
- Teachers assign higher scores in science evaluation exercises to boys as opposed to girls (Spear, 1984; Mitchell and Hoff, 2006). There are science teachers who feed the expectation that boys are better and perform better than girls in science evaluation.
- Boys are more often asked higher order cognitive questions than girls (Tobin et al., 1990; Mitchell and Hoff, 2006). Many teachers instinctively ask boys to answer tougher questions in science classes, believing that girls are unable to answer at that level of cognitive reasoning.

- Males have more chances to conduct experiments, perform demonstrations and manipulate science equipment (Jones & Wheatley, 1990). Teachers often endorse the perception, confirmed in the qualitative part of this research, that boys are more practical and 'better with their hands' and therefore give them first choice when it comes to doing practical experiments in science classrooms.
- Males raise their hands and call out answers more often than do females, and even when females raise their hands more often than males, the teacher is inclined to call on the males first (Baker, 1987; Jones & Wheatley,1990). Boys take up the mantle of expected 'superiority' in science classes, as found in the qualitative section of this research, when responses are called for in science classrooms. Some teachers affirm this by allowing boys to respond ahead of girls.

Solutions to contend with the disadvantage and deal with such inequities that girls and minorities experience in science education, and which facilitate gender equity in science classrooms, are recommended by Rennie (1998) as: providing learners with science skills and experiences with science equipment to motivate them to study science; considering learners' background experiences and providing them with the learning environment and assessment tasks to facilitate the improvement of their science knowledge; using the curriculum to make science more inclusive – this would facilitate the rethinking of the type of learners who are given access to science; and challenging the hegemony of science and in so doing bring about a more socially 'just' science.

Communication in science classrooms presents powerful opportunities for the promotion of gender equity; it is the framework wherein girls' and boys' gendered perceptions of science are either fostered or broken down. Classroom interaction between males and females, not only on a teacher-learner but also a learner-learner level, influences the gender equity climate of science lessons. For example, in a study which observed verbal interactions between learners during whole-class and small-group discussions, and assessed learners' perceptions of gender differences in discussion in science classes, Guzzetti and Williams (1996) found that: refutational discussion, where science concepts were debated, favours males; girls spoke rarely in whole-class debates where scientific concepts had to be refuted or debated; boys were most likely to display aggressive language during discussion; boys consistently perceived girls' questioning as exhibiting a lack of knowledge in physics; when girls do not participate in whole-class discussions it is because they are afraid, lack self-confidence, fear violating social conventions or feel intimidated; small groups do not necessarily facilitate females' participation unless grouped by gender and the males in the group would most often take the lead whereas females would be confined to setting up the equipment or recording data; where females were placed in same-sex groups they naturally became more active participants

where they felt more secure; males and females displayed contrasting language usage styles whether in whole-class or small-group discussions – whereas boys displayed a more independent discussion style, girls displayed a more collaborative, consensus-reaching style; and learners are well aware of gender disparity in classroom discussions whereas teachers are usually unaware of it.

Ritchie (2002) also refers to verbal communication in the discussion of the dynamics of gender in science education, when exploring the social dimensions of science classrooms. Ritchie (2002) requested teachers and researchers to see gender as a multifaceted and complex social construct that intersects with other factors like status and power. In re-examining previous data, Ritchie (2002) looked at the complexities of gendered interactions amongst the learners in groups whilst they were busy with science activities and found that learners bring into these activities the 'social baggage' of previous experiences in social settings and that this impacts their current interactions. This resonates with similar comments by other researchers (Miller et al., 2006; Jones et al., 2000; Baker and Leary, 1995; Kahle et al., 1993) of the multifaceted nature of the gendering of science and that the gendering of science takes place in a social context, specifically within interpersonal relationships. In a qualitative study located in a Grade 10 science classroom in British Columbia, Canada, Gaskell et al. (1998) observed a Grade 10 gender equity project. Their findings demonstrated that different assumptions about gender, pedagogy, equity, and the representation of data can be made. They came to the conclusion that:

> "Gender is multifaceted and complex, and intersects with other factors such as race and class." (Gaskell et al., 1998, p.874)

Teachers' behaviour reinforces the notion that boys involve themselves more successfully than girls in science and substantiates the view of Staberg (1994) that teachers' actions in class promote the 'hidden curriculum' that reminds learners that science is for boys. Teachers foster stereotypical attitudes towards girls in science classrooms (Kahle & Meece, 1994; Baker, 1987; Parker et al., 1996) and Scantlebury (1995) adds that, if educators unwittingly accept gender role stereotypes, this could influence learners' gendered perceptions of science even further. Duncan (1989) also showed that gender stereotyping of science in classrooms had a small but recognisable effect on the participation and achievement of girls in science.

In an attempt to respond to the challenge of bringing about gender equity by countering the effects of the gendering of science, Head and Ramsden (1990) point out that teachers can promote the appeal of science to a greater range of girls than just those who have a genuine interest in science by teaching 'girl-friendly' science lessons. Furthermore, Rennie (1998) suggests three strategies for science teacher education and research in the debate on the role of gender and equity in science education:

1. Inviting changes in attitudes, beliefs and behaviours in teaching practice (McGinnis and Pearsall, 1998) so that the gender role stereotyping of science is considered as part of the delivery of the lesson and skewed perceptions are challenged opportunistically;
2. Adopting instructional strategies that engage girls and boys equally (Koballa, 1997) so that from the outset and in a planned way science is presented as a pursuit for both genders equally; and
3. Seizing intervention opportunities (McGinnis and Pearsall, 1998) for breaking down perceptions of science as a male domain that present themselves during the presentation of science lessons.

Adding to the idea of teacher gender equity interventions in gendered science classrooms, Tobin (1997) suggests that science teachers should become researchers in their own classes in an attempt to combat the effects of gender in science education. In addition, teachers should intervene in verbal and non-verbal classroom activities where gender inequities exist, by ensuring that learners are made aware of the situation (Guzzetti & Williams, 1996). Grouping learners by gender for small-group discussions, promoting self-confidence in girls by providing them with an intellectually safe environment, and developing acceptable, gender-fair notions of science are ways in which Guzzetti and Williams (1996) suggest the gendering of science in the classroom interaction environment can be countered.

As a response to the gendered nature of science classrooms, Carlone's (2004) description of the evolution of gender equity research to investigate the creation of a more gender-fair science and science education calls for teaching practice in science classrooms that is more focused on accounting for girls' biological, cognitive and social differences, encouraging more equitable classroom treatment and requiring transformation in the science curriculum. The focus of the research thus shifts from looking at the differences between girls and boys to the science classroom and the manner in which teachers, learners and the curriculum interrelate to give rise to gender inequalities in science education. One of the practical implications of the delivery of the science curriculum is that teachers do not expect good performance from girls in science in classrooms (Spear, 1987) as a consequence of the manner in which science is presented by teachers. In this regard, Murphy and Whitelegg (2006, p.281) contend that:

> "The contents, contexts and ways of approaching problems and investigations in physics more closely reflect what boys, more than girls, engage with outside school, and those activities associated with what culture defines as masculine rather than feminine attributes."

The above remarks lead one to support Easlea's (1981) and Kelly's (1985) argument and to realise that it is no wonder that women and girls are alienated from science. Another implication of

the gender role stereotyping of science as a male pursuit is that it influences the attitudes of girl learners towards the subject as they make decisions about careers (Chamber, 1983; Koch, 1989).

In her concluding remarks, Rennie (1998) sees positive progress in effecting gender equity in science classrooms when she comments that science teachers' and researchers' understanding of gender equity has developed and broadened to an interpretation which takes cognisance of the way that science is used in society and education to privilege members of dominant cultural and social groupings, including gender, and to challenge this hegemony (Rennie, 1998). Naidoo et al. (1998, p.92) also feel strongly about the broader societal imperative of gender equity when they state that:

> "These are disparities of class, gender, race, location and poverty. Often the issues of equity affect several overlapping disadvantaged groups, such as rural poor girls, making them groups that are the most disadvantaged."

Gender equity in South Africa is more acutely focused on social justice because the country's Apartheid past disadvantaged groups of people because of race. This resulted in the double disadvantaging of Black South African women since, apart from political disadvantage owing to their disenfranchisement, they also had to endure disadvantage because they were women and more so because they were Black women. With this background, Naidoo et al. (1998) are of the opinion that the gender equity challenge for South African science teachers lies not only in the classroom but also in their participation in the larger society, to ensure that the political will and social consciousness to achieve gender equity succeeds. Gender equity programmes encounter the masculine image of science as being contributed to by educators and accepted by learners. In a cross-national, comparative study of the implementation of a gender equity initiative in science education undertaken in the USA and Australia (Kahle, Parker, Rennie, Riley, 1993) which focused on educator beliefs and attitudes, educator behaviour in the classroom and learner beliefs and attitudes, the pervasiveness of the gender effects on science education was shown to be particularly critical in its effects on vulnerable learners. Girls were categorised in this group because of a lack of prior experience and low levels of self-confidence. The crucial role that teachers play in creating gender-fair science classrooms was emphasised when the study (Kahle et al., 1993) revealed that, despite the American and Australian teachers' receiving some form of equity training, on returning to the American classroom, researchers found that organisational aspects of the science classrooms had reverted to ways that disadvantaged girls. In the findings from the Australian segment of the cross-national study (Kahle et al., 1993), girls were perceived to have lower levels of self-confidence by fellow girls as well as teachers.

In conclusion, when looking at the dynamics of social interaction in science classrooms, a need exists to influence the way in which teachers teach science, especially to girls. Teacher training

programmes present opportunities where this influence can be optimally articulated. Haggerty (1996, p.25) suggests that "concerns ... about how science is presented in schools have been ignored largely in most science teacher education programs" and she feels that these are issues which must be addressed if we truly are concerned about increasing the participation of women in science.

3.4.4. The curriculum

One of the main issues in the discourse on the differences in the perceptions of science and the participation rates in science of girls as compared to boys is the gendered image of science as it is presented in science textbooks and the larger science curriculum. Mitchell and Hoff (2006, p.10) are of the opinion that:

> "If we want more women in the sciences, we need first to investigate the ways that the sciences are taught in our classrooms. Researchers and curriculum designers should investigate the ways to change the curricula..."

The impact of the gendered nature of school science textbooks on the perceptions of learners about science needs to be seen against the background of the gendered nature of textbooks generally, across the curriculum. The use of gendered images and text is part of a pattern of the unequal representation of gender in textbooks. This unequal gender representation takes the form of visual images such as illustrations and photographs, or gender role stereotyping, language usage and terminology. Whilst this pattern is changing in favour of an improved balanced in the representations of males and females, the predominantly masculine image of science in learner textbooks persists.

In their study of medical science textbooks, Alexanderson, Wingren and Rosdahl (1998) caution that the manner in which content, illustrations and language are dealt with in textbooks may be affected by the nationality of the authors, owing to differences in cultural norms which influence how gender is expressed and valued. This confirms the view that subjective, gendered images of science and scientists are presented to learners in science classrooms and that socio-economic and cultural influences impact the developers of science teaching resources and subsequently influence learner perceptions.

3.4.4.1 Textbooks across the curriculum

Turner-Bowker (1996, p.463), in applying a feminist analysis and outlining the understated effects of gender stereotyping in children's literature through the use of language, frames the discourse on the role that textbooks play in education when she states that:

> "Books provide role models; from this, children learn what behavior is acceptable for them, for their peers and for adults around them."

The language and images portrayed in textbooks serve as mediums through which learners receive messages about gender stereotypes. They use these messages to perpetuate the gender stereotype (Turner-Bowker, 1996). The content of textbooks facilitates the interplay between the 'messages' that society sends and learners' self-image or identity. In so doing, it plays a powerful role in fostering or breaking down gender role stereotyping. In their view of the potential influence of textbooks, Sunderland et al. (2001) regard learners' gender identity as being in a continual state of flux and thus amenable to further influence and shaping.

Joshi (1994) and Evans and Davies (2000) are of the opinion that textbooks, as the agents of the transmission of society's values and attitudes, are powerful tools in shaping learners' views of society, and that the content and illustrations found in textbooks cultivate positive or negative attitudes in learners about self-image, gender roles, occupations and chances in life. Elgar (2004) enhances the previous comment on the role of textbooks when she considers the messages that textbooks send to be potentially highly influential because of their ability to affect the learning opportunities and gender identity of learners. In an affirmation of different gender roles for males and females that textbooks portray, a study of the textbooks used in Nepalese primary schools (Joshi) revealed that the textbooks endorse challenges for males but subservience for women; the researcher found that in all the textbooks surveyed, women were portrayed in 'non-occupational' activities such as cooking. In reviewing studies of gender equity in educational materials, Rifkin (1998) states that, whilst gender inequities were of different 'shapes and sizes', the existence of sexism in instructional material needs to be acknowledged, since it holds important repercussions for learning.

Even in teacher education textbooks where one would expect a greater degree of balance in gender representation as regards illustrations and content, Zittleman and Sadker (2003) found that a gender bias was evident in curriculum materials in the following forms:

- invisibility – where minimal treatment was given to women;
- stereotyping – where individual attributes and differences of women were denied;
- imbalance – where the work and sacrifices of women were omitted;
- unreality – where for instance, sexual harassment of women was dismissed;
- fragmentation and isolation – where the role of women was isolated from the mainstream;
- linguistic bias – where masculine terms and pronouns were exclusively used; and
- cosmetic bias – where, in a publication, an illusion of the inclusion of women and their contributions was created.

3.4.4.2 Science textbooks

Studies specifically targeted at investigating the gender bias and gender role stereotyping in science textbooks have focused on illustrations or representations of males and females which reinforce gender role socialisation, the text itself as it pertains to the number of people mentioned by gendered name, the use of language as it relates to the use of gendered terms and pronouns, and philosophical assumptions about science as it is portrayed in science stories.

Potter and Rosser (1992) view the textbook as an important element that influences the teaching of science: in their study of school science textbooks they searched for the factors that have the potential for deterring girls' interest in science. Whilst Potter and Rosser (1992) in their study of life science textbooks found no proof of direct sexist language or the transmission of occupational stereotypes through the use of language, they did uncover a significant bias in favour of male images in textbook illustrations, which created the impression that males are the norm as far is science is concerned.

Elgar (2004) regards it as important that the illustrative representations of males and females be equally portrayed in school science textbooks, which are an important resource during science lessons. This would ensure that learners get a more balanced view of the participation of girls and boys in science and science careers. In their concern for the subliminal and theoretical messages that a difference in the ratio of males to females in science textbooks present to boys and girls, whilst Bazler and Simonis (1991) noted an improvement in the ratio of male images to female images in the high school chemistry textbooks they surveyed, a negative difference of fewer girls' than boys' images still exists – this, they felt, still contained the possibility of creating the impression that science is for males.

In her study of three of Bruneian (a country in Southeast Asia) lower secondary science textbooks, Elgar (2004) looked at how females and males are represented in both illustrations as well as in the text. As an important aspect of gender equity, Elgar (2004) found that in illustrations, whilst the sex of the person portrayed was clearly apparent, the dress was distinctively male or female, and whilst the number of people mentioned by name was very low, not one female scientist was mentioned: this meant there were no female scientist role models to which girls could aspire and where photographs of women were used, the women appeared to be passive. With regard to the survey of the text used in the science textbooks, Elgar (2004, pp.885-886) also found:

- only two instances of the explicitly gender-neutral formulation 'he or she' and
- in the use of generic language as a source of gender bias, there was no instance of the use of masculine gender pronouns being used to include females.

Elgar's (2004) findings exposed a distinct gender imbalance in the illustrations in favour of males, confirming the masculine image of science to Bruneian girls and boys. However, in the text there was a balanced approach, indicating that not all science textbooks are skewed by presenting an exclusively masculine image of science.

In their gender analysis of medical textbooks Alexanderson, Wingren and Rosdahl (1998) confirm the gender bias prevalent in science textbooks in which the male is considered the norm and the 'invisibility' of gender differences as articulated by Zittleman and Sadker (2003), comprising individual biological or psychosocial differences that women present. Alexanderson, Wingren and Rosdahl (1998) indicate that most of the books surveyed were written by men and express the view that, in the textbooks surveyed, the stereotypical sex pattern is consolidated in the text and the examples used.

In looking at a different aspect of the representation of the female and male in science textbooks, Milne (1998) examines the implications of the philosophical correctness of science stories as they are told in science textbooks and informs that the stories uphold a particular set of philosophical assumptions about science and present embedded notions about the nature of science. In contextualising the social norms implicit in stories in science textbooks, Milne (1998) expresses the view that science stories relate to culture via social norms, and impart a concept of the culture of science which helps learners to make sense of science in their classroom discussions. Milne (1998, p.182) implies that the portrayal of women in science stories is tokenistic and that these stories depict women scientists as having "defied convention to make it in a man's world", as exceptions to the rule and as having had to work very hard to achieve what they have – as if, under normal circumstances, male scientists would find it less challenging to be scientists. The portrayal of children emulating the science career roles of men and women in textbooks continues to present images which perpetuate gender role stereotyping in science.

The masculine image of science as portrayed in learner science textbooks has therefore been shown to advance the 'hidden curriculum' which promotes male dominance and is not supportive of the aspirations of girls; the textbooks give credence to the belief that science is a male pursuit and is best suited to males.

3.5 The tertiary science education sector

The under-representation of girls in physical sciences at secondary school level can be extrapolated to physical sciences faculties at universities and in the science career field. Whilst the influence of socialisation and culture play a meaningful role in determining girls' perceptions of, attitudes to, and interest in science, the decision as to whether they will launch into a physical

sciences career path is impacted significantly in science classrooms in primary and especially the GET Phase of junior secondary school. This is where the formal choice is made whether to choose science as a field of study in the pre-tertiary, senior secondary FET Phase of education.

In expressing their views on the under-representation of women in physics, from high school through to university physical sciences faculties, Hazari and Potvin (2005, no page number: Electronic Journal) listed three viewpoints to explain this under-representation: inherent differences, which expressed the controversial, politically incorrect view of socio-biologists that "females have genetic influences that lead them to being disinterested in physics"; socialised differences, which point to men and women being socialised differently to be 'less inclined towards physics' by society, family and education; and the culture bias of physics, alluding to the masculine image of physics which is transmitted pedagogically, academically and socially. The aforementioned are discussed in some detail in Chapter Eight of this thesis. The debate about the possibility that genetics influences women's lowered inclination towards science is inconclusive and requires much investigation but the socio-cultural influences on girls and the impact of the masculine image of science resulting in the under-representation of women in science has been researched such that clear indications have emerged of this under-representation.

In suggesting reasons for the differences mentioned above, Hazari and Potvin (2005) recommend as an intervention that the focus of physics be directed to a fundamental change in the field itself. Feminists have suggested approaching established beliefs in science with a different perspective and a more diverse, girl-friendly science in which cognisance is taken of the particular 'sensitivities' of women, their nature, as well as the focus of science, such that 'bad science' is avoided. Ivie et al. (2001) in their report on the International Study of Women in Physics mention the demands of child care and discriminatory attitudes (such as the assumption that women cannot do physics) as barriers that women face in physical science faculties of universities in various countries when attempts are made to increase the numbers of women in physics. The demands of family commitments were also mentioned as impediments to the improvement of the involvement of women in physics by Padayachee et al. (2002) in their report on the International Conference on Women in Physics. The stereotyped social expectations of women as nurturers and caregivers thus impact on their access to the study of science at universities. These issues form part of the recognition required by policymakers and those in authority that women in the science arena need to have conditions more suited to their specific life challenges as mothers, nurturers and caregivers and that these issues do not impede full participation. These are also the issues that impact the 'pipeline' from secondary education institutions that feed girls and women into tertiary science faculties at universities.

3.6 Gender, science and the social context

The broader social context including the family and popular media, comprising television, film, music video and increasingly, rapidly developing interactive computer technology, has been shown to play an increasingly powerful role in spreading stereotypical gender images amongst young people.

3.6.1. Family and home environment

A child is socialised via parents' and significant others' cultural beliefs and practices. As the child's personality and character develops, this socialisation is strengthened through relationships, formal education and engagement with the popular media. A feature in the child's personal development is the cultivation of a sense of gender and a stereotyped gender role that will mature further, and in which will be fostered an attitude to, perception of and interest in science and technology. Scantlebury (1995), in looking at the role of gender in science from a social constructivist perspective, comments that this sense of gender originates early in childhood development and remains as a stereotype.

Learners start their formal education in primary schools, having spent a number of years at home under the influence of society and culture regarding their gender roles vis-à-vis science and technology. The education system, through the dynamics of the school, teachers and the curriculum, then starts a formal process of influencing learners' further relationship with science.

In a study involving boys and girls from one to eight years old, which focused on whether parents explained more often to boys than girls while using interactive science exhibits in a museum, Crowley et al. (2001) reveal that, through their actions, parents see science as a stereotypically male activity. Crowley et al. (2001) demonstrate in the study that parents were more likely to explain to boys during informal science activity than to girls and state that the findings may be more noteworthy because differences were observed in the rate of parents' explanation to children as young as one to three years of age. This suggests that parents may be involved in the creation of gender bias and stereotyping in science learning years before children's first experience in a science classroom. A study amongst Canadian adolescents (Bouchard et al., 1998) established that where school performance is concerned, parents generally offer similar affective support to their female and male adolescent children, although small differences based on differential socialisation practices for males and females did emerge. The researchers interpreted this as an encouraging sign of less gender role stereotyping during parental involvement in schooling. In their research on parental involvement and attitude to their adolescent children's science schoolwork, however, Bhanot and

Jovanovic (2009, p.56) conclude that their research conducted in Illinois, USA, "sheds important light on parental socialisation that is differentially effective for boys' and girls' science beliefs", and that:

> "…particular parental behaviors can play an important role in creating a positive climate in which girls' attitude towards science develops." Bhanot and Jovanovic (2009, p.55)

There are thus signs that parents have different ways of mediating science to their boy and girl children. This emerges more forcefully in the quantitative data that were gathered in this research. In the career choices to which learners report that their parents want them to aspire, it would appear that fathers want their boys to follow science careers rather than careers in other disciplines.

3.6.2. Science images in the popular media

The role of the media – movies, comic books, television – has been identified as a significant source of information and a means by which students and learners assimilate images of scientists. The media is complicit in connecting power as a 'major' aspect of masculinity and thereby advances the association of science with masculinity by promoting a philosophy that says that science, as a pursuit in which power plays a significant role, is a male pursuit. O' Shaughnessy and Stadler (2008, p.382) maintain that:

> "Power is the major attribute that is seen as the key signifier and definer of masculinity in the media and in the real world."

In a study conducted in Ankara, Turkey, that investigated the perceptions of scientists of elementary school children from different socio-economic backgrounds, Buldu (2006, p.130) remarks that:

> "Most of the children involved in the study were greatly influenced by the science they saw depicted on TV, and many of them used what they had seen in their portrayal of the scientist."

Cakmakci et al. in a study investigating the effects of teaching interventions that were conducted with Grade 6 learners in Turkey noted that:

> "Several researchers argue that comics, novels, newspapers, movies, television and other forms of mass media contribute significantly to the reinforcement of student's stereotypical images of scientists." (Cakmakci et al., 2010, no page numbers - published online)

Children are learning from the popular media that scientists are predominantly White and male (Finson, 2002) and this reinforces their perceptions of science and science education. The images they encounter in their socio-cultural environment are being confirmed and strengthened by the images that they see in the media; this further solidifies the identities that they associate with science and science education.

O' Shaughnessy and Stadler (2008) refer to the internalisation of 'patriarchal expectations' of women and the media's visual representation of women as sexual objects as being the focus of feminist analysis of the way in which the media portrays women, particularly in advertising. This type of imaging that is associated with women confirms their 'status' as 'not fit for science' and belongs in a category that says that women need to fit into the expectations that men have of them. This type of imagery feeds into the perceptions that women and girls are not suited to science. They conclude that:

> "Many contemporary advertisements offer something positive to women but ultimately reassert aspects of traditional femininity." (O' Shaughnesy and Stadler, 2008, p.375)

Learners are thus prone to stereotyped images of scientists as they interact with the media. The proliferation of cellular phones and other relatively low-cost, interactive media devices increasingly contribute to the type of images that learners have and that perpetuate gender role stereotypes. In a paper that attempted to provide an overview of the research on people's perceptions of science and scientists, Finson (2002) expresses the view that consistent exposure of children to the media teaches conceptions about science and scientists and influences their attitude to it. In his investigation of studies done on stereotypical perceptions of scientists, Finson (2002, p.341) concludes that stereotypical perceptions of scientists are persistent; that there has been a subtle shift in the stereotype in that the "mythic" element of the scientist's image has become less and less prevalent; and that even most learners from minority groups draw images of Caucasian scientists. Finson (2002) acknowledges that the origin of the factors that influence the stereotypical perceptions of scientists have been inferred by researchers rather than established.

Turner-Bowker's (1996) reference to a comment by Brookes-Gunn and Mathews (Turner-Bowker, 1996) that "media sources play a part in early gender role development" confirms the early transmission of a culture that promotes gender role stereotypical images. When Turkish Grade 5 learners were questioned in research about perceptions of scientists about 'which media sources they used to gather information about scientists', they ranked music channels, local radios and local and national newspapers as important or very important categories of information (Türkmen, 2008, p.58). Learners' attitudes to science are influenced by the images of scientists that they come across in the popular media, which in turn impacts the career choices that they make. A lack of imagery of women scientists creates a negative attitude and Kelly (1987) proposes that learners' negative attitudes towards science lead to the under-representation of girls in science faculties and women in science careers.

3.7 Concluding remarks

The chapter dealt with literature studies around gender, science and science education with respect to four main areas: a review of research in this regard; gendered responses to science amongst learners, including the development of a science identity, gender-related differences in attitudes and interests amongst learners, and the learners' pursuit, or not, of further science studies in the form of the subject choices that they make; the impact of the school environment on learners' perceptions of science, encompassing gender and schooling, different types of gender-based schools, the interactional dynamics in science classrooms, the science curriculum and the resources used to deliver it in classrooms; and the social context in which science education takes place, including the family and home environment and the images of science in the popular media.

The literature on the masculine image of science and the disparity in the participation rates of girls in science and women in science careers point to a situation that, whilst assuming more prominence as a result of the increased attention it is receiving, continues to exasperate researchers and to highlight the issues. In developing a science identity, the impact of socio-economic and cultural factors on learners' lives, coupled with the type of environment that is created by parents in homes, have a significant effect on whether the girl or boy learner's curiosity and interest is stimulated to the extent that the child will become active in science pursuits. The gender differences that exist between boys' and girls' interests in and perceptions of science are the outcome of a number of socio-economic and cultural factors 'operating' in the learners' live world. The influence of race and class cannot be discounted as factors that affect learners' interest in and perceptions of science. It is abundantly clear from the literature review that science classrooms are crucial to countering the science perceptions of learners. The roles of teachers and the curriculum are pivotal in creating the climate where gendered perceptions of science and science education can be mediated. Lastly, the extent of the influence of the modern media in perpetuating imagery that entrenches existing gender stereotypes, including the images of science and scientists, is seminal in that it creates a situation where messages are continually being 'beamed' to learners about gender stereotypes.

There is a need for heightened awareness of the status of girls in primary and secondary science education and women in tertiary science education and science careers in the context of changes of the role of women in society that have taken place at the behest of 'advances' in society, stimulated by developments in economics and technology. Whilst there appears to be progress in the manner in which girls and women are seen to be an equal and integral part of society, encompassing its social, cultural and economic systems, the mainstreaming of the role and place of girls and women

as a move away from their deep-rooted 'alienation' is a way off from the goal of unmitigated gender equity in all spheres of society and its functioning.

The scrutinising of empirical studies has identified the social forces that function at various levels in society in influencing the gender perceptions and subsequent actions of boys and girls in science and science education. These forces translate into barriers to girls' participation in science education and women's participation in science careers. At school level, the role of teachers appears to be crucial in, firstly, being aware of the own gender attitudes and perceptions that they bring into the science classroom and secondly, being aware of how these gender perceptions are mitigated and mediated to ensure equal participation levels of girls and boys in science classrooms. Teachers' cultural and social stereotypical views of the role of women in society impact the manner in which they interact in science classrooms and there is a need to counter this practice. Learners also enter the education system with their own gender attitudes, perceptions and stereotypical views of the role of girls in science and science education. Learners have an opinion of what a science identity constitutes and often don't see themselves as fitting into that identity. These 'science identities' are created in the microclimates in which children grow up and are nurtured in society, such that by the time learners engage with formal schooling, they have already formed an idea of who 'does' science. The nature of science in the curriculum and the science curriculum itself needs to be reworked in order to make it more accessible and inclusive so as to extend its interest beyond its traditional limits of masculinity, race, class and ethnicity (Hughes, 2001), thus transforming the male stereotyped, existing masculine identity that science has.

Differences in learners' interest in and attitudes to science have been pinpointed in the literature. Whilst there is general acceptance that learners enter the formal schooling system with equal interest in science, there is acceptance that these interests increasingly diverge as learners progress through the system. The result is that girls and boys emerge from the schooling system with differing interests in science that are related to the content and the nature of the science. Whereas boys are more comfortable with 'hard core' sciences like engineering, girls appear to be more comfortable with affective sciences that have to do with caring and nurturing, like medicine and environmental science. The type of school, whether single sex or co-educational, does not appear to hold any answers as to why girls' and boys' interest in and attitudes to science are divergent.

The gendering of science takes place in a social context and interaction in science classrooms plays an important role in counteracting or neutralising the effects of the gendering of perceptions of science and science education. The literature indicates that currently something is amiss in the interaction, as schools continue to reproduce the unequal relationships between girls and boys. The teacher's interaction with girls and boys in science classrooms is pivotal in breaking down the

development of hegemonic masculinities that influence perceptions of science and science education. Peer interpersonal interaction in the school environment, where stereotypes abound, would appear to be more challenging to counter as learners conform to the norms and values of society.

Empirical research also foregrounds the nature of science teaching and the manner in which the curriculum is delivered to learners as a vehicle for reproducing the inequality between boys' and girls' participation in science. Textbooks are specifically mentioned as portraying images of mostly white, male scientists and a lack of women scientists, aside from using text that consolidates stereotypical gender patterns.

Reference is also made in empirical research undertaken about gender and science to the popular media as a significant source of information for learners, as representing women in subservient contexts: this has an effect on how they see science and science education.

The findings from the empirical research present a picture of continuing gendered perceptions of science in the form of gendered stereotypes. Education, family and culture continue to reproduce these gendered perceptions.

CHAPTER FOUR
The study

4.1 Introduction

Research in the field of gender requires that researchers immerse themselves in a thorough understanding of feminist research methodology and apply a critical gendered lens in research. Feminist literature insists that researchers be circumspect and take extra measures to ensure that the research findings are authentic and, whilst acknowledging that a measure of bias is always present when qualitative data collection is conducted, encourages self-reflexivity, views that are critically constructive and that promote transformation. This is pertinent especially if the research is about girls or women and is undertaken by men because of the history of the marginalisation of women in certain areas in society (for example, economics and politics). The practical aspect of the research methodology sets out with this in mind.

The chapter details the aims of the research undertaken and the questions that it intended to answer. The manner in which the research has been designed, including a discussion of the quantitative and qualitative methods of data collection, is set out. In the research design, the rationale for using triangulated methods of data gathering, the methodology that was used, the participants and the pilot study that was conducted, are discussed. The site of the research and the school community's location within the country's geographic, social and economic echelons is also detailed. The participants and the manner in which data were obtained from selected respondents in the in-depth interviews, are described, and an analysis is done of the demographical and biographical data received from the quantitative survey questionnaire. The necessary ethical considerations that need to be exercised when doing research, especially because it is being conducted on non-adult learners, are pointed out and the chapter concludes with self-reflexivity.

4.2 The study

This section outlines the structure of the study, the manner in which it was conducted and the characteristics of its participants. It discusses the circumspection that needs to be undertaken when engaging in feminist research and sets out the questions that guided the research. In discussing the methods that were used in conducting the research, the reasons and the value of utilising quantitative as well as qualitative methods of data collection are explained. This section also provides details of the institution that was the site of the research and the structure of the curriculum programme that it offers. A description of the learner cohort is provided and aspects of their science performance that motivated and relate to this study are indicated. The section also describes the development of the instruments that were used to gather data, with reference learners' responding

to the research questions, and the interviewers. The procedure for collecting the data is discussed and the demographic data are analysed to give an indication of a profile of the learner cohort that participated in the research. This profile included establishing the economic level of the learners' families with regard to level of access to technology and the educational level of their parents. A discussion of the motivation for focusing on specific areas that relate to science in the home and school is also embarked on. The chapter concludes with a discussion of the ethical guidelines to be considered when doing research. The final section is a self-reflexive look at the organisation of the study and how it was conducted.

4.2.1 The research methodology

The location of the topic in a feminist theoretical framework necessitates that cognisance be taken of the debates surrounding the methodological praxis involved in research and specifically fieldwork in this area. With regard to the necessary circumspection needed with the participation of girls in qualitative data-gathering, the comments by Mbilinyi (1992, p.35) that refer to the "ideology, personal identity and social location of the researcher" as important aspects of the personal location of the interviewer, were noted and utilised as a guide when the qualitative section of the research was conducted. Kelly, Burton and Regan's (1994, p.33) opinion that:

> "...feminist research focuses on how women's lives are constrained by the actions of men individually and collectively and the strategies girls and women find to resist, challenge and subvert..."

is particularly noted, given the focus of the study. In this regard, Edwards (1990) mentions the three principles to be considered when conducting feminist research: that women need to address their lives on their own terms; that feminist research should be on and for women (Kelly, Burton and Regan, 1991); and that the researcher should be part of the production process of the research. In concurring with the view that women should be involved in the research where issues of gender are pertinent, Wolf (1996) speaks of employing the technique of immersion in using a methodology which allows the researcher to observe the culture from within. The practical outcome of this is the use of researchers and/or fieldworkers who are conversant with the social dynamics of the race, class and status of the participants in the research. Fieldworkers should be aware of the societal profile of the communities from which the participants, including their race, religion and economic background and should, in the case of the quantitative in-depth interview, be of the same gender as the participant. Fieldworkers should also be aware of the generally held stereotypical views of the community from which the participants come.

Kelly, Burton and Regan (1991) outline the key definers of feminist research, namely that it uses qualitative methods, empowers the participants and that the research is directed towards social change in the conditions of women. The in-depth interviews conducted with girl learners sought to raise their awareness of gender issues and, in so doing, to empower them with a view to improving the way in which they viewed the opportunities in their lives. This study aims at creating more awareness around the effects that the male image of science is having on the participation rates of girls in science and science education. The above views on the fundamental components of gender research have been noted and have found practical expression in the manner in which the in-depth interviews and the survey questionnaire were conducted.

Mbilinyi's (1992, p.56) suggestion that, in adopting a feminist research methodology in researching gender issues, the way to manage bias is to bring "value premises and judgments" into the terrain of the research process, has thus found practical expression in the qualitative aspect of this research: bias is acknowledged as containing opinions based on the societal norms values of the interviewers. Mbilinyi's suggestion requires that circumspection be exercised in selecting interviewers for the boys and the girls. Interviewers of the opposite sex to the interviewees could bring to the process a natural gender bias developed from adherence to socio-cultural norms and values and in this way make interviewees apprehensive about expressing themselves for fear of contradicting acceptable social positions on gender issues. The suggestion would also encompass adhering to ethical standards of research, especially since the research terrain is gender, such as acquiring permission for the learners to be interviewed because they are considered to be minors according to South African law and giving them the option of not participating in the interview.

4.2.2 Research aims and questions

The research aims to ascertain whether there is a significant difference, on the basis of gender, in a sample of Grades 7, 8 and 9 learners' perceptions of and interest in science and science education and to explore the areas from where these differences emanate. The aims of the research are also to explore learners' subjective perspectives and attitudes to science and science education in the social, economic and cultural context of their lives. The influence of the school environment, encompassing interaction with peers, school educators, the precepts of the curriculum and teaching and learning resource materials, on the learners in Grades 7 through 9, is also investigated.

The research is predominantly focused on exploring the influence of social, familial and cultural contexts on girls' and boy's perceptions of, attitudes to, and interest in science and science education and the subsequent careers to which they aspire. The research also aims to explore

differences across language, race, grades and gender, to establish how learners' responses can be understood and what inferences can be drawn from them.

The research questions of the study may be grouped into three main areas:

1. Gender differences in learners' perceptions of, interest in and activities related to science
    a. Do learners' perceptions of and interest in science and reported activities differ according to their gender?
    b. To what extent do gender differences with respect to learners' perceptions of, interest in and activity in science differ with grade advancement?
    c. What is the extent of learners' reported engagement with science via electronic and print media and verbal communication?
    d. To what extent do learners report being active in science activities outside of formal schooling, and is this gendered?
    e. Are learners' perceptions of the role and importance of science differentiated by gender?
2. Learner perceptions of gender differences in science classrooms
    a. Are learners' reported experiences and perceptions of the dynamics in science classrooms differentiated by gender?
    b. Are learners' perceptions of their and other's engagement with science differentiated by gender?
    c. Are learners' reported anxiety levels in science classrooms differentiated by gender?
    d. The impact of social contexts: family, home, the media and community on learners' perceptions of science
        a. To what extent do learners' reported perceptions subscribe to gender stereotypes about science, scientists, science education and science careers?
        b. Are there gender differences in learners' reported science-related activities at home?
        c. What are learners' reported perceptions of the gender of scientists as portrayed in the media?
        d. What role does race play in learners' perceptions of science?
        e. What are learners' reported perceptions of and messages about their parents' views on science and science careers?

4.2.3 The research design

This study included both quantitative and qualitative research methods, a survey questionnaire and in-depth interviews with a smaller sample drawn from the larger survey sample. De Vos's (1998) opinion that qualitative data complement quantitative data, thus increasing the reliability of the observations, served as a reason for complementing the quantitative survey questionnaire with semi-structured in-depth interviews in this research. Duffy (1993), cited in De Vos (1998, p.359), terms this complementing and contextualising "data triangulation". In substantiating De Vos's viewpoint, Mason (2002) points out that the researcher cannot separate facts from their context; quantitative data need a context which gives social meaning to the data, improves the authenticity of the findings and enhances the quality of the responses from the participants. The researcher uses the qualitative data in a sensitive manner that encompasses a contextual and social understanding and interprets all the data collected with this in mind.

Whilst the quantitative method would yield statistics of learner responses that would support and add numerical weight to assumptions and comments, qualitative data would enrich these assumptions and substantiate or refute the statistical data. The nuanced responses that language use during in-depth interviews allows for, adds more meaning to the somewhat 'clinical' responses to the quantitative survey questions. During interviewing, interviewers are able to pick up coded comments with hidden socio-cultural messages that provide anecdotal evidence. Using both qualitative and quantitative data-gathering methods also allows for cross-checking of the responses to similar issues raised in both forms of data-gathering that were used.

The quantitative data collection, by means of the survey questionnaire, was done before the qualitative collection that was done by means of the semi-structured, in-depth interview. This was purposefully done to immerse the learners into the topic of gender and science so as to raise their awareness of the issues and so that they could express a more considered opinion. More importantly, this also allowed the researcher to probe issues that emerged from the findings of the survey to enable a richer, more in-depth understanding and reflection.

4.3 The participants

4.3.1 The research site

A secondary school, Mitchells Plain Secondary (pseudonym), located in a suburb of Cape Town, the largest city in the Western Cape Province of South Africa, was the primary site of the research. Learners from other primary 'feeder' schools in the immediate vicinity of the primary

research site were also included in the research. The school is located in a predominantly Coloured[3] area consisting of communities relocated to the area as a consequence of the previous government's policy of racial segregation that formed part of the Apartheid ideology. As such the school was created under the authority of the House of Representatives, the parliamentary chamber created for the governance of Coloured people.

The school was opened in April 1980. At the time that the research was undertaken there were 1374 learners at the school of whom 665 were girls and 704 were boys. The school caters for Grades 8 to 12 and offers education in both English and Afrikaans mediums of instruction. There are 44 educators on the teaching staff, four security personnel and six non-teaching staff. The school also had access to the services of a social worker.

Two grades of the senior phase of the General Education and Training (GET) curriculum, Grades 8 and 9, as well as the Further Education and Training (FET) curriculum covering Grades 10 to 12, are on offer at the school. The FET subject fields offered are Commerce, Science, Computer Science and general subjects such as various languages and History. Despite the curriculum's varied nature, the school focuses on Mathematics and Physical Sciences and, as such, has been a participant in the Dinaledi Schools Project since the inception of the project in 2001. As far as appointments are concerned, the staff is reasonably stable. I was the principal of the school from 1994 to the end of January 2009, after having been appointed to the staff as a department head of Science and Mathematics in 1984. The school is regarded by the Western Cape Education Department (WCED) authorities as one of the better-managed and better-performing schools in the Mitchells Plain area and has received recognition for excellent results within the context of the schooling environment.

Data in Figure 4.1 below, extracted from the school on an annual basis, indicate the participation rates of boys and girls in Physical Sciences at the start of the FET Phase of education (which consists of Grades 10, 11 and 12). The data indicate a clear average difference of 5.84% between the numbers of boys taking the subject as compared to the number of girls, favouring the boys, in the five-year period. This difference stood at 12.9% in favour of the boys in 2005. Figure 4.1 below indicates the participation rates for the Physical Sciences in Grade 10 for the years 2001 to 2005. Figure 4.1 is followed by a graph in Figure 4.2, indicating the trend with regard to participation rates over the five-year period.

The data indicate that at the end of Grade 9, 22.94% of the girls compared to 28.78% of the boys are selecting physical science in Grade 10. The trend line of the graph indicates that the

[3] During Apartheid all schools were racially and ethnically segregated. See Footnote about racial terminology in Chapter 1.

participation rate for girls decreases acutely per year whereas that for boys increases, albeit gradually. This indicates that the gap in the participation rates of Grade 10 boy and girl learners in Physical Sciences is worsening, to the detriment of girls. Even at this singular grade and superficial level, the data indicate that there are problems with the number of girls entering the FET Phase science arena, with the number of girls taking Physical Science in Grade 10 dropping. The science 'pipeline' that learners enter and that leads to science courses being taken at tertiary level starts here.

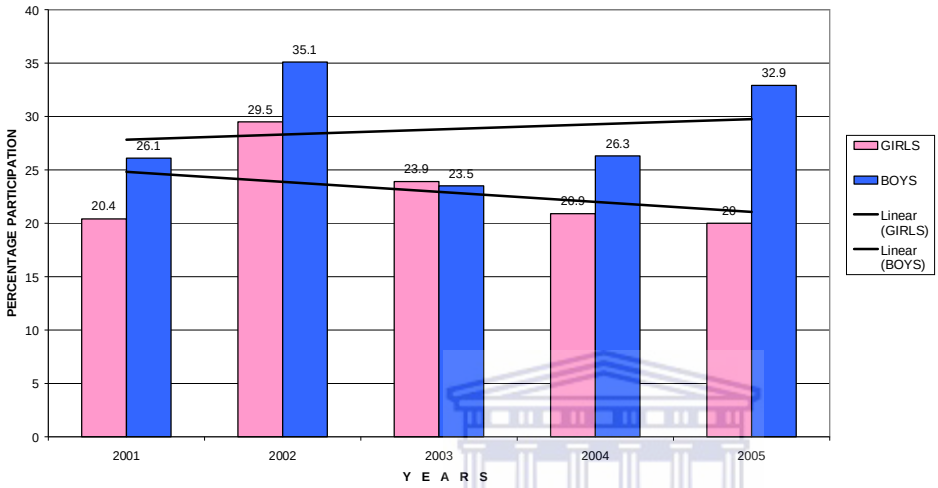
FIGURE 4.1: **Comparison of girls and boys participating in science in Grade 10: 2001 to 2005**

A SECONDARY SCHOOL IN MITCHELLS PLAIN							
YEAR	GIRLS			BOYS			
	TOTAL ENROLMENT	SCIENCE ENROLMENT	%	TOTAL ENROLMENT	SCIENCE ENROLMENT	%	**% DIFFERENCE**
2001	180	38	20.4	142	37	26.1	**-5.7**
2002	173	51	29.5	111	39	35.1	**-5.6**
2003	197	47	23.9	170	40	23.5	**+ 0.4**
2004	181	38	20.9	171	45	26.3	**-5.4**
2005	185	37	20.0	167	55	32.9	**-12.9**

1. WCED ANNUAL SURVEY FOR ORDINARY SCHOOLS 14 MARCH 2001
2. WCED ANNUAL SURVEY FOR PUBLIC AND INDEPENDENT ORDINARY SCHOOLS 14 MARCH 2002
3. WCED ANNUAL SURVEY FOR PUBLIC SCHOOLS 11 MARCH 2003
4. WCED ANNUAL SURVEY FOR PUBLIC SCHOOLS 2 MARCH 2004
5. WCED ANNUAL SURVEY FOR PUBLIC SCHOOLS 1 MARCH 2005

FIGURE 4.2

SECONDARY SCHOOL: BOYS' AND GIRLS' PARTICIPATION RATES IN SCIENCE IN GRADE 10: A LONGITUDINAL PICTURE



4.3.2 Participants: survey questionnaire

The quantitative survey questionnaire was administered to 600 English medium, Grades 7, 8 and 9 boy and girl learners. Of the total of 600, 200 each of Grades 7, 8 and 9 learners were surveyed. The data were collected at the end of the 2008 academic year, in the fourth term, when the learners completed that grade of the GET (General Education and Training) course.

The learners participating in the research survey study spanned the GET band and were in Grades 7, 8 and 9. Retrieving information from the whole GET band enabled one to assess the development, if any, of learners' thoughts and opinions about science, science education and science careers in this phase of schooling. Whilst a longitudinal study could have been more advantageous, a cross-aged (Reid and Skryabina, 2003), cross-grades approach required a shorter timeframe and in this study, fewer logistical arrangements. According to Reid and Skyrabina (2003, p.512), "the cross-aged approach … allowed the development of 'snapshots' of attitudes held by pupils simultaneously at various stages of schooling and can be made in a very much shorter timeframe".

In the South African schooling system, generally, and particularly in the Western Cape Province, Grade 7 forms part of the primary school. The questionnaire was presented to the Grade 7 learners of eight surrounding primary schools. These learners had been accepted at the school for Grade 8 for 2009. The make-up of the survey group, comprising primary and secondary school learners allows for the added advantage of comparing the perceptions of science of the learners in

the final year of primary schooling, Grade 7, with those who are beginning their secondary school education in Grade 8. The Grade 8 and 9 learners who participated in the survey were already enrolled at the school. The Grade 7 learners who participated in the survey are those learners who were required to write tests in Mathematics, English and Afrikaans, as well as to complete a social survey questionnaire and do a reading test so that educators could assess their strengths and weaknesses in preparation for their entering Grade 8 at the secondary school in 2009. The questionnaire for this research was conducted when they came to the school for the testing. The learners had been recruited for the research and permission had been sought from them and their parents to participate in the research, prior to their coming to the research site. Most of the learners are from the Coloured community and reside in Mitchells Plain. There is a slowly growing group of Black African learners at the school who reside in the nearby township of Khayelitsha, which is populated by mainly Black African residents.

Of the total number of learners who participated in the survey questionnaire, 41% were boys and 59%, the majority, were girls. The cohort of learners that participated in the research comprised learners who were accepted into Grade 8 at the secondary school that was the site of the research, and those who were already 'resident' in the school. The larger percentage of girls would not skew the results since percentages were used. The ages of the learners varied from 12 to older than 16 and they were represented, percentage-wise in the following manner:

FIGURE 4.3: **Ages of learners participating in the survey questionnaire**

AGES IN YEARS	%
12	8.7
13	30.6
14	36.4
15	17.5
16	5.5
16+	1.3

The ages of the learners indicate that they could mostly be grouped in the adolescent phase of their development with the majority falling into the age group 13 to 14 years old. 84.5% of the learners fall into the 13 to 15 age group, which is in line with official government policy that stipulates the ideal ages that learners should be in a grade. This group of learners could thus be seen as progressing as expected through the grades.

Regarding religion, whilst the learners were presented with choices to select from in the questionnaire, the data that were generated were categorised into two main groups, Christianity and Islam, these being the two main religions in the area. Christian learners were presented choices

comprising a variety of different Christian denominations commonly found in the area: Catholics, Anglicans, Baptists, Seventh Day Adventists, Moravians, Apostolics and adherents to the Dutch Reform Church. Below is a table in Figure 4.4 indicating the percentages of learners adhering to the different religious denominations.

FIGURE 4.4: **Percentages of learners adhering to the different religious denominations**

RELIGIONS	%
Islam (Moslem)	31.0
Catholic	14.8
Anglican	9.4
Baptist	4.8
Seventh Day Adventist	0.5
Moravian	0.7
Apostolic	24.7
Dutch reformed Church	1.9
Other Religions	12.3

56.8% of the learners could be grouped into those following Christianity and 31% follow Islam.

The data indicate that 56.3% of the learners speak both English and Afrikaans at home while 38.3% of learners indicated that they speak English only at home. The learners who indicated that they speak Afrikaans only, Xhosa only or Xhosa and English at home represent just over 1% for each group. 94.6% of the learners thus speak English at home. This indicates how widespread the use of English is as a medium of communication. There is a generally held view that parents, in homes where English was not the home language, are sending their children to English medium schools so as to enable their children to access the perceived economic advantages of being able to communicate in English. The main medium of the school is English although there is a rapidly diminishing number of learners for whom the language of learning and teaching is Afrikaans.

The learners were requested to indicate which significant adult they lived with most of the time. 61.5% indicated that they live with both their mother and father. 38.5% thus lived in circumstances where there aren't both parents in the home. Almost a quarter (23.3%) of the learners indicated that they live with their mother only and the rest responded that they live with 'Granny and Grandpa' (7.7%), an uncle or aunt (3.2%) and their father only (2.3%). The question was not raised whether there were other family members, outside of the nuclear family, living in the home. A significant percentage of the learners thus do not live in circumstances where there is the traditional family unit of mother, father and children as a single unit, living together. The fact that almost a quarter of the learners indicated that they lived in a family where there is only a mother and thus the

father figure is absent, would indicate that mothers play a significant role in social interaction in the family. Thus mothers' opinions of masculinity and the image of science could have a significant impact on the children.

By way of attempting to define class and socio-economic standards, learners were requested to indicate the jobs of their parents. Their responses were classified into science (engineering, scientific, architecture, medical, computers) and non-science (everything else) jobs and the data that represent the sector in which parents are employed, show that parents are mostly employed in the non-science sector.

Learners' exposure to science in the home is mediated by the socio-economic and cultural status of the household as determined by its purchasing power. In this respect a number of questions attempted to establish whether the learners have had exposure to science applications, through access to domestic, electrical science equipment or machines in their homes. These questions also tried to establish the economic status of the household through verifying the existence in the home of appliances that indicate the purchasing power of the family. The science-related resources that are present in learners' homes present opportunities to facilitate and foster development of an interest in science in girls and boys. The questions were extracted from the South African Advertising Research Foundation's Living Standards Measure (LSM), a multivariate market segmentation index used as a marketing research tool to establish individuals' wealth based on their standard of living (Haupt, 2009). In order to differentiate between diverse groups in a population, it uses the index to establish commonalities amongst people. In so doing it allows one to "differentiate between people with different behaviour patterns and group together those people with similar behaviour" (Haupt, 2009, p.2). The LSM scale is divided into ten segments, each equated to a socio-economic level. The scale consists of an item bank, in which each item has a numeric value, of household appliances or machines, and was drawn up to gauge the economic potential of the household by establishing what appliances its members have been able to acquire. When one adds up the value of each item that exists in the household, one gets a quantified indication of its buying power that then allows one to infer what the socio-economic status of the household or individual is. For the purposes of this research some items from the original scale were omitted from the calculation. It must also be borne in mind that not all the relevant questions were answered by the learners. The particular level that the learners' family is placed on allows inferences to be made and connections drawn to gender-stereotyped perceptions garnered from other responses in the survey. The breakdown of the placement of the learners' households, with respect to the measuring of living standards by grade and gender, is tabulated below in Figure 4.5:

FIGURE 4.5: **Learners' household living standards**

GRADES	7		8		9	
GENDER	GIRLS	BOYS	GIRLS	BOYS	GIRLS	BOYS
LSM 10	0	0	0	0	0	0
LSM 9	78	54	90	71	88	62
LSM 8	35	23	25	12	28	16
LSM 7	6	3	0	1	4	2
LSM 6	1	0	1	0	0	0
LSM 5	0	0	0	0	0	0
LSM 4	0	0	0	0	0	0
LSM 3	0	0	0	0	0	0

On the ten-segment scale, the learners' households are concentrated at levels eight and nine, with a few located at level seven. This indicates a fair level of basic applied science resources being present in their homes which points to a particular standard of living and implies that learners participating in the survey have access and exposure to, albeit domestic, electrical science applications.

The implication here is also that, whilst gender plays a role in which aspects of science learners would be interested and become active in, the economic status of the household is more important a factor than gender in determining the level of exposure to science at home. This opens up the broader debate of the link between access and exposure to science and economic status as determined by purchasing power, determined by income level. This link can be extended to the education system and more specifically the financial potential of the school that the learner attends, to expose her or him to science activities and experiences. The practical implication of the financial potential of the school that learners attend, and unfortunately the reality here, is that schools located in poorer communities do not have the same potential to purchase science equipment that would facilitate learner exposure to science as schools located in more affluent areas. This limits the level of exposure to science that learners have in schools in poorer communities. Social class as determined by economic status thus mediates learners' access and exposure to science at the school level. The link between socio-economic class and science and science education is evident. The presence of applied science resources also necessitates a certain level of understanding of how these appliances or resources work and this would imply a functional level of scientific theoretical knowledge.

The homes of the learners who participated in this research, as sites where perceptions of science are cultivated, assume greater significance when the ability of the learners' parents to encourage and facilitate discussion, in especially science topics, is gauged. It would appear that there are limitations in this area if one associates parents' ability to foster discussion with their education level as indicated in Figure 4.6 below, since the majority of parents' educational level is reported to

be in the FET Phase, although a sizeable percentage of learners appear not to know the educational level of their parents.

FIGURE 4.6 **QUESTION 14 (MOTHER) AND QUESTION 15 (FATHER)**
What is the highest grade that your mother or father passed?

RESPONSE NUMBER	RESPONSE CATEGORY STATEMENT	NUMBER PER CATEGORY	%
1	I don't know	168	28.0
2	Lower than grade 8	16	2.7
3	Grade 8 or grade 9 (GET)	33	5.5
4	Grade 10, 11 or 12 (FET)	207	34.5
5	Technikon / College	27	4.5
6	University	42	7.0
	Percentage of learners who did NOT respond to this question	107	17.8

The apparent limited ability of parents of the learner cohort in this research to facilitate discussion on science issues, as indicated by their limited educational level in Figure 4.6 above, with the implication of the concomitant lack of encouragement of girls from selecting science subjects in the FET Phase, is also referred to by van Langen (2006, p.90) in research on sex-related differences in the determinants and process of science and mathematics choice in pre-university education, conducted with Dutch pre-university learners:

> "Girls from a higher social class (indicated by the parental level of education) have parents with a higher level of educational aspirations for them, which leads to the choice of more science and mathematics subjects than by girls from a lower social class."

4.3.3 Participants: in-depth interviews

A proportionate sample of 4% of each group of 200 learners was selected for the in-depth interviews. The number of learners actually interviewed was 26, since two girls who formed part of the pilot study's in-depth interview group were also included. The sample comprised 12 boys and 14 girls; eight learners (four boys and four girls) were from Grade 9. Eight learners (four boys and four girls) were from Grade 8 and ten learners were from Grade 7 (six were girls and four were boys). Two of the learners, one boy and one girl are from the Black African community and the rest were from the Coloured community. The two Black African learners had spent all their years of primary schooling at a Coloured primary school whilst living in Khayelitsha, a Black African township adjacent to Mitchells Plain. The ages of the learners ranged from 12 to 16: four were aged 12, ten were aged 13, eight were 14, three were 15 and one boy was 16 years old.

Pseudonyms have been used to protect learners' identities. The pseudonyms given to the learners have been matched to their gender and none of the learners' names have been replicated. Where applicable, names related to social attributes like religion and race have been retained. In

addition to the pseudonyms, codes were allocated to the learners to enable the reader to get an idea of the profile of the learner who is commenting on a particular issue. The codes used are the following:

G = Grade of the learner (Grade 7, 8 or 9)

M = Male gender of the learner

F = Female gender of the learner

The number that follows the indication of the gender is the number allocated to the learner in the transcription of the substance of the interviews.

Details of the participants are provided in Figure 4.7 below.

FIGURE 4.7: **Participants in the in-depth interviews**

NO.	PSEUDONYM	CODE	GENDER	AGE	GRADE	NO.	PSEUDONYM	CODE	GENDER	AGE	GRADE
1	AMINA	G7F01	Female	12	7	14	CATHY	G9F14	Female	14	9
2	GADIJA	G7F02	Female	12	7	15	JOEY	G7M01	Male	13	7
3	RUWAYDA	G7F03	Female	13	7	16	CLINT	G7M02	Male	13	7
4	CHRISTELLE	G7F04	Female	13	7	17	ROBERT	G7M03	Male	12	7
5	QUARNITA	G7F05	Female	13	7	18	TERENCE	G7M04	Male	13	7
6	JEAN	G7F06	Female	12	7	19	BRUCE	G8M05	Male	14	8
7	JOSEY	G8F07	Female	13	8	20	ACHMAT	G8M06	Male	14	8
8	SUMAYA	G8F08	Female	13	8	21	ROWAN	G8M07	Male	14	8
9	ZAINAB	G8F09	Female	13	8	22	UTHMAAN	G8M08	Male	14	8
10	RUKAYA	G8F10	Female	13	8	23	LANCE	G9M09	Male	15	9
11	LEBOGANG	G9F11	Female	14	9	24	GRAHAM	G9M10	Male	16	9
12	SANDRA	G9F12	Female	14	9	25	PETER	G9M11	Male	15	9
13	KAREN	G9F13	Female	14	9	26	THABISO	G9M12	Male	15	9

4.4 Data collection

4.4.1 Quantitative research instrument: the survey questionnaire

A group-administered questionnaire was used to elicit data from the participating learners. The overall approach in the design of the survey questionnaire was first to establish the biographical, socio-economic and educational backgrounds of the learners, and to some extent of their parents or guardians, and then to ascertain differences in learners' perceptions of and attitudes to science.

Section 1 of the questionnaire was focused on gathering demographic, biographical information about the learner, her or his family make-up, religious affiliation, language of communication and the education levels and careers of parents or guardians. The section aimed to categorise the learners' demographic and biographical information, to use the data to compare information gathered in other sections of the questionnaire and to establish how this information

intercedes, with a specific gender focus, in the learners' perceptions of science and science education. Closed-ended questions were set. Various responses to the statements or questions were supplied and learners were expected to select a particular response. The study that was primarily used to generate or access questions or statements for this section was the Trends in International Mathematics and Science Study (TIMMS) (2002) study.

Sections Two to Five contain questions or statements, categorised in sub-sections, about learners' attitudes to, beliefs about and perceptions of science, science education and science careers. The themes and concepts covered in the survey questionnaire were covered in more detail in the questions set in the in-depth interviews, conducted after the questionnaire was administered, that is discussed later. Section Two also attempts to establish the extent of gender differences in learners' interest in science and how this difference manifests in the younger Grade 7 learners in comparison to the older, more mature Grade 9s. Learners' responses were elicited via sub-sections of questions that were set to differentiate between categories of science interest and activity. The sub-sections are linked to the research questions and comprised: interest in science, to establish whether gender impacts this interest; access to applied science appliances, to ascertain the level of science resources in the home; participation in science-related activities in and around the home to establish whether there are gendered perceptions of science activities around the home; reading and talking about science, to establish how gender influences interaction relating to science; engaging in science activities of a more formal, educational nature to establish whether the choices are gender-related; and what careers parents expected them to pursue, with a view to establishing the science or non-science nature of the parents' career aspirations for their children.

Possible gender-related trends in learners' interest in science were investigated through learner responses. A semantic version (very little, a little, a lot, quite a lot, very much) of a Likert scale was number-coded (1, 2, 3, 4, 5) to simplify analysis. Responses were examined for gendered differences in learners' interest in science.

The design of the survey questionnaire was premised on the focus of the research. Its objective was to establish the extent to which gender intercedes and mediates the perceptions of GET learners of science and science education. The survey questionnaire is contained in Annexure 12.1 and focused specifically on four areas where learners' lives interceded with science and science education:

1. Their own personal perceptions
2. The school
3. The home and
4. Interaction in society.

Whilst a few of the questions or statements were generated by the researcher, most of the questions and statements contained in the questionnaire were from similar studies that were undertaken (Baker, 1987; Duncan, 1989; Jones and Wheatley, 1990; Oppenheim, 1992; McGinnis and Pearsall, 1998; Joyce and Farenga, 1999; Spellman, 2001; TIMMS, 2002; Dhindsa, 2003; George, 2006) and are referred to in a more detailed discussion below of the sections that made up the survey questionnaire. Some of the questions were modified to suit the local requirements (for example, the South Africa education system's use of names for particular grades in a phase like GET that covers Grades 7, 8 and 9). The questions were organised under themed headings that contained the questions or statements around specific concepts that were being surveyed. Care was taken to ensure that the questions, where required, were neutral and the researcher ensured that the questions or statements were linked to the focus of the study.

4.4.1.1 Science and related perceptions and attitudes

Comment [LG1]: Number?

Section 2 of the survey questionnaire requested responses concerning information about the learners' science interests and activities in order to ascertain whether science interest has manifested itself practically in and around the home situation, including accessing media and parents' career choices for their children. The section was aimed at statistically measuring and comparing gendered and other differences in interests in science and learners were presented with statements about access to information about science. Responses were also requested of learners about the careers to which their parents would want them to aspire. The activities listed were applied science-related and contained examples of more formal engagement with science in the form of reading science-related articles in the print media, or electronic contact via television or computers. The types of responses vary from a simple positive or negative response to the presentation of a Likert scale on which learners had to select the strength of their response. The statements or questions were accessed from the TIMMS (2002) study, as well as from instruments used in studies conducted by George (2006) and Joyce and Farenga (1999). The questions or statements about computer access and some science-related activities were self-generated because of their relevance to local circumstances.

4.4.1.2 Reported experiences in science classrooms

Section 3 requested responses from learners about their interaction in science classrooms and their perceptions about it. Learners were required to respond to statements about their experiences in science classrooms as they pertained to their performance and that of the opposite sex, their future intentions with regard to pursuing science academically, their impressions of their science teachers, and their actions and state of mind during science lessons. Learners were presented with four responses that were numbered, in a semantically intensifying, vocabulary scale, and were required to indicate their preference. The statements or questions were accessed from research that

had previously been conducted and in which the validity of the statements or questions had been established.

4.4.1.3 Perceptions of science, scientists and science careers

Section 4 was aimed at eliciting from learners their views on science and scientists, science careers, expected behaviour in science careers, their opinions of science activities, the nature and value of science and their expected performance in science. Learners were presented with four responses that were numbered, in a semantically intensifying, vocabulary scale and were required to indicate their preference. The statements or questions were accessed from research that had previously been conducted and in which the validity of the statements or questions had been established. Research from which statements or questions were extracted or adapted includes the work of Oppenheim (1992) and Spellman (2001). Some statements or questions were self-generated to make them relevant to local circumstances. The information gathered would be analysed to establish the extent to which gender mediated the responses of girls and boys.

4.4.1.4 Views on science and the media

This final section 5 of the survey questionnaire comprised statements or questions that related to the print and electronic media and their portrayal of science and scientists. The aim was to use the demographic and biographic learner information to establish to what extent gender mediated the learners' responses to how the media portrayed and represented gender in publications. Learners were presented with typical science-related issues and images that are reported in the media and had to select a response that was gender-specific.

4.4.2 Qualitative research instrument: the semi-structured, in-depth interviews

The semi-structured, in-depth interviews were set up so that the responses could increase the reliability of and confirm the quantitative data. In eliciting verbal responses from learners, the in-depth interviews aimed to improve the context of the data received from the quantitative survey questionnaire.

The interviewers were issued with written instructions (see Annexure B) so as to limit possible personal interpretations of how to conduct the interview. Interviewers were required to confirm that the learner had parental permission to be involved in the interview, were willing to be interviewed and for the interview to be tape-recorded. Interviewers were required to set time frames, put the interviewee at ease and explain the purpose and nature of the interview. Interviewers were required to gather demographic and biographic information about the learners being interviewed and in this regard, learners' gender, age, grade and future career aspirations were recorded. Information

garnered about their families consisted of whether they were living with their parents, their parents' occupation and how many siblings they had, as well as their ages. Information about interaction in the learner's family so as to establish general relationship patterns (for example, decision-making in the family) was also gathered. The interview also established whether there was a history of science study or scientists in the family. Learners were also to be asked about their close friendships so as to establish whether they mix freely with learners from the opposite sex.

The interviewers were also supplied with the aims for asking specific questions so that they could have an idea about the reasoning behind the questions and the areas for the categorisation of the learner responses into the focus of the research, gender and the perceptions of science and science education.

The interviewers were required to officially commit themselves to confidentiality regarding the content of the interviews and a letter to this effect was supplied to the researcher.

4.5 Procedures for data collection

4.5.1 Survey questionnaire data

The survey questionnaire was piloted at a primary school in a neighbouring suburb of the school where the main study took place. The pilot study was conducted with 30 Grade 7 learners, 15 boys and 15 girls, from a primary school in Lentegeur, which is a suburb in Mitchells Plain. All the learners in the pilot study were Coloured. The social, cultural and economic context and environment of the learners in the pilot study is similar to that of the learners in the main study. The learners also have similar personal and biographical characteristics to those who were involved in the main study.

The pilot study was conducted to test the design of the research in order to expose any deficiencies so that these could be rectified before the questionnaire was used in the main study. It was aimed at developing a *modus operandi* with regard to the practical implementation of the questionnaire and at ascertaining whether there were any major flaws with regard to the level of language used in the questions, whether the questions were easily understood, the grammatical correctness of the questions, the time it took to complete the questionnaire and the structure of the questionnaire itself.

The fieldworker, a Coloured woman, who conducted the pilot study and the subsequent in-depth interviews with four learners who participated in the pilot study was also required to make comments on the efficacy of the questionnaire and the presence of any design flaws which could become obstacles to the eliciting of responses from the learners. Aside from minor grammatical and numerical errors, and structural issues relating to the spacing of the questions, the comments from the learners involved in the pilot study indicated that there were no serious problems with the

questions and the structure of the questionnaire itself. It was, however, deemed necessary to give the learners some information about the reasons for the research and the background to the drawing up of the specific questions of the questionnaire.

With regard to ascertaining the relevance of the questions in eliciting responses about science, the questions in the pilot study exhibited a clear gender-based difference. In-depth interviews were conducted with four learners, two boys and two girls, from the pilot study group. The records of these in-depth interviews are also included with those of the main study and bring the total of learners involved in the qualitative section of the research to 26. Statistical indications arising from the analysis of the statistics from the quantitative section of the pilot study were used to focus on specific responses emerging from the main quantitative survey questionnaire.

The final survey questionnaire that was used in the study was duplicated in hard copy format and the learners responded to the questions on this form. The responses were entered manually into a computer using a spreadsheet programme, the Microsoft Excel software programme. The 200 Grade 7 learners were seated in the school hall. Young, male and female, experienced teachers were with them to administer the questionnaire and to do any trouble-shooting. The same procedure was followed with 200 Grades 8 and 9 learners currently at the school where the research was conducted. Learners were all brought to the same venue, the school, which made logistics easier. They were excused from their normal periods to proceed to the school hall to complete the questionnaire.

When learners had completed the survey questionnaires, teacher facilitators who had administered the process, collected them.

4.5.2 In-depth interview data

All the interviews took place on the same day and measures were taken to ensure that the learners were safe in coming to the interview and returning to their schools. The recordings of the interviews were transcribed by the interviewers and the transcriptions as well as the recordings were handed to the researcher. The aim of the interviews was to explore participants' attitudes to, beliefs about and perceptions of science and what appears to influence these attitudes, beliefs and perceptions, in the context of the group's social, educational and economic profile. The in-depth interviews also sought to explore differences in the attitudes, beliefs and perceptions of the learners towards science and related matters from year to year and grade to grade in the GET Phase of education.

The in-depth qualitative interviews of the 26 learners were conducted by two young, Coloured research assistants, one male and one female, who are teachers at the school. They have similar ethnographic, cultural, social and religious backgrounds to the interviewees in order to compensate

for the possible intimidation of the girl learners by older, male interviewers from a different ethnographic grouping and of male learners by female interviewers. The reason for this approach was to make the interviewees feel emotionally comfortable and trusting when they responded to questions regarding their attitudes to, beliefs about and perceptions of science, science education and choice, or not, of science as a subject in the FET Phase of their education. The in-depth interview also sought to ascertain whether a career choice in a science field might have been subject to parental or other adult influence. This was done to elicit responses from the girls in particular, to take cognisance of, in the opinion of Kelly, Burton and Regan (1994, p.28):

> "...the complex interplay of multiple sources of oppression (and areas of privilege) in women's lives."

Edwards (1990, p.486) refers to this contextualising of the interview situation for girls as a "sex-based trust" between women researchers and women interviewees.

The aim of utilising young, same-sex interviewers was also to foster interactional dynamics which would promote responsiveness amongst the interviewees, to break down any hierarchical relationships which might develop if older interviewers from one sex only were used, and to develop the intersubjectivity suggested by Kelly, Burton and Regan (1994). In keeping with this, the boys were interviewed by a male and the girls were interviewed by a female. The latter-mentioned authors go further with this interviewee contextualisation and refer to a set of presumptions, namely:

- that women find it easier to share their experiences with other women;
- that this is always of personal benefit, and
- that the sharing of gender will enable any difficult or painful accounts to be dealt with sympathetically and effectively (Kelly, Burton and Regan, 1994, p.35).

The consideration for using young interviewers of the same sex as the interviewees in this qualitative data-gathering phase of the research was also guided by Edwards (1990) and Wolf (1996), who refer to the exploitative possibilities of the unbalanced power situation stemming from differences in gender in fieldwork. The use of the interviewers in this research thus attempted to avoid a 'crisis of confidence' and an unequal power relationship on the part of the interviewees towards the interviewers.

The need for interviewers to be selected from the same socio-cultural context of the interviewees, in this research, from the Coloured community, was also for the interviewer to be immersed in the culture of the interviewee as also recommended by Warren (1988), who terms the practice 'cultural contextualisation'. Warren (1988) mentions the skin colour of the field worker as a crucial factor in the interviewer's need to fit into the culture of the interviewee. This approach in the research's qualitative data-gathering phase is further substantiated by Wolf (1996), who restates the

idea of cultural immersion as a way of downplaying privilege and difference in the in-depth interview in feminist social science research. Wolf (1996) goes on to state that race may dominate interaction between the researcher and the person or group being researched if its potential impact is not moderated.

The in-depth interview was structured in the sense that interviewers were briefed before the time about the *modus operandi* of the interview. A semi-structured interview schedule (see Annexure B) was used to guide the interview. The interview was focused on the views of learners on women and their entry into traditionally male careers, men's entry into tasks and careers traditionally regarded as careers meant for women, the media's depiction of persons in science-related careers, experiences in science classrooms and perceptions of science teachers. The interviewers were fully briefed regarding setting the scene for the interview, what questions to ask, and the context and reasoning behind the questions. Interviewers made the interviewee feel comfortable, introduced themselves, completed the demographic information required from the learners, and noted the date and time of the interview. They established the social, economic and cultural context of the interviewee and were requested to limit the questions to those that were printed with the instructions. Interviewers were requested to establish the decision-making hierarchy in the interviewees' homes and whether there was a history of any family members being scientists. Interviewers were remunerated for conducting the interviews and transcribing the audio into hard copies.

4.6 Analysis of the quantitative and qualitative data

4.6.1 Analysis of the quantitative data

The learner responses to the survey questionnaire items were counted and these counts expressed as percentages for each response, grade, gender or age group. Response data on specific items in the survey questionnaire were compared on the basis of age, grade or gender in order to establish differences, if any, in perceptions of science and science education. Response data were, where necessary, grouped according to key variables of age, grade or gender in order to highlight and analyse trends for example all the boys' responses across grades were grouped and compared to all the girls' responses across grades in order to compare boys and girls perceptions on particular issues regarding gender and science. Descriptive statistics and comparisons across the different variables were conducted with the assistance of Microsoft Excel 2010. Once the data were quantified, they were categorised into aspects that focused on testing and responding to the research questions, and analysed and interpreted in terms of these research questions. The categorical data that were presented "in the form of counts in various categories" (Rice, 1995, p.483) were then analysed.

A “univariate analysis” (De Vos, 2001, p.204) was utilised for individual survey questionnaire items where a variable’s data were gathered, analysed and interpreted. Some of the data were also analysed using bar graphs that portrayed frequency distribution. Use was also made of trend lines on the graphs to indicate differences in response statistics, so as to present a more focused interpretation.

Use was also made of “bivariate analysis” (De Vos, 2001, p.224) that presented the association and relationship between variables and allowed for comparisons between girls’ and boys’ responses, especially to highlight differences. The Pearson correlation coefficient was also used to establish “the strength or degree of relationship between two variables” (De Vos, 2001, p.231). The statistical significance of the data was also tested using the chi-squared test that established whether the results of the data analysis were not due to chance and to substantiate and enhance the interpretations.

4.6.2 Analysis of the qualitative data

The transcriptions of the interviews were categorised into themes that focused on responding to the research questions and tabulated separately for girls and boys, also by grade, to facilitate easier analysis and comparison on gender and grade or maturity level. The transcriptions of the interviews were then scrutinised to establish whether there were differences in girls’ and boys’ responses to specific issues and questions raised by the interviewers. Note was taken of the language use of the learners and “words and phrases in respondent’s own vocabularies” (Schurink in De Vos, 2001, p.337) that depicted colloquial, nuanced responses were categorised into themes that responded to the research questions. The categorisations indicated in the guidelines issued to interviewers alluded to foci and whilst these were not part of the analysis process, its connection to the analysis process is centered on organizing the learner’s responses into a coherent analysis of their views in reaction to issues of gender and science. These responses also formed the basis for comparing the perceptions of boys and girls to establish the degree to which they were stereotyped and the extent to which the responses were similar or different according to grades and maturity levels. The responses of the learners and the themes that emerged when these responses were analysed, were also compared to learners’ responses in interviews conducted in similar research (Frosh et al., 2002; Swain, 2003). The analysis of the learners’ responses in the in-depth interviews was subjected to coding and layering to expose different levels of interpretation. Firstly, an initial, somewhat superficial reporting was done of the learner responses. This included the numbers, grades, gender and percentages of learners expressing similar views to particular questions or statements. This was followed by coding at the broadest level that generated a wide range of codes.

These were then analysed and themes generated that included more in-depth analysis of their responses to unearth deeper meanings and foundations of their discourse. To this end learner responses were analyzed to reveal responses based on themes or issues some of which emerged from the literature survey, for example perceived gender differences based on physical strength, intelligence and skill levels as well as stereotyping, the possible influence of women's empowerment rhetoric and parental, media and societal influences.

4.7 Ethical considerations

Official authority was sought and gained from the Western Cape Education Department and the school governing body to conduct the research amongst the Grades 7, 8 and 9 learners. All standard ethical procedures for research with human participants were adhered to. Informed consent was sought and gained from the learners themselves as well as from their parents and/or guardians to conduct the surveys and in-depth interviews. Learners and their parents and/or guardians were assured of confidentiality and anonymity and that they may leave the research at any point. The research process was subject to the Rules on the Ethics of Research of the University of the Western Cape (UWC) and the study was ethically approved at UWC. Research assistants were required to sign a research agreement, attached as Annexure X, which required them to abide by the rules on the ethics of research of the UWC.

Since this is not an affective area of research, it was not expected that respondents could come to any emotional or psychological harm during the survey questionnaire and in the conducting of the semi-structured, in-depth interviews. Learners and their parents were given consent forms to complete the week before the survey questionnaire was conducted and also before the in-depth interviews took place (see Annexures H and I). The interviewers and the researcher regarded the responses of the learners as private and confidential and in no way was this confidentiality breached or violated. Learners and their parents and/or guardians were assured of anonymity and that they could withdraw from the research process at any point. The learners and their parents were not deceived in any way whilst the surveys and interviews were conducted or as regards the results of the survey.

Care was taken to ensure that the interviewers were competent and that they understood that their actions were subject to ethical and moral standards as required by education authorities and national standards for conducting research amongst learners.

There was collaboration between the researchers and the sponsors of the research and the University of the Western Cape. The findings of the research will be made available to the University

of the Western Cape as well as education authorities whose permission was sought to conduct the research.

The integrity of the research was protected at all times and care was taken that interviewers did not fabricate or falsify data or findings. In the publishing of the research, care will be taken to subscribe to ethical publishing practices.

The research, its procedures and process were transparent and the results will be disseminated freely and openly, subject to the conditions of the sponsor and the University of the Western Cape. There was awareness that the research was being conducted amongst learners who are regarded as a vulnerable group and counsellors were available in case there were emotional issues that emerged. At no stage was there any need to deviate from worldwide standards of ethical practice.

4.8 Self-reflexivity

Apart from minor logistical challenges, the learners' completion of the survey questionnaires and the conducting of the in-depth interviews proceeded without significant hitches.

The conducting of the survey questionnaire raised expected challenges with regard to learners' level of reading skills and the extent of their vocabulary. In this regard, facilitators were on hand whilst the learners were completing the survey questionnaire to answer learners' queries while exercising caution not to influence their responses. Care needed to be taken, in clarifying to learners what was required, that learners were not unduly influenced to respond in a particular manner. The dissimilarity in reading skills levels can be ascribed not only to the different cognitive and reading skills levels of the individuals in the diverse group of learners but also, specifically in the case of the Grade 7 learners who came from different primary schools, to the different levels of teaching skills at these schools.

Despite assurances to the contrary, some learners were apprehensive when completing the survey questionnaire, regarding it as a test of their ability rather than, as was carefully indicated to them, a simple data-gathering exercise. Whilst letters were sent to the participating primary schools for disseminating to the parents of the learners, few learners returned the completed letters of consent. Follow-up requests did not meet with much success. This could also be attributed to the fact that their visit to the school was not only to participate in the research but also to complete tasks to assess their cognitive level with regard to reading and mathematics and their focus could have been distracted.

Nevertheless, all 600 learners completed the survey questionnaire, although not all statements or questions were responded to in the manner required, rendering a very minor quantity,

in different statements, un-useable. This can be seen in the statistical analysis where only the number of learners who responded to the question was used in the analysis.

With regard to the in-depth interviews, it is apparent that learners do not have a clear idea of what a 'scientist' is, what kind of work scientists perform and who could be considered scientists, even though this challenge was anticipated and the interviewers asked to explain the concept to the learners. Despite a pre-interview training and discussion with interviewers and despite written instructions being supplied, it is apparent that their style of questioning, as regards voice intonation and emphasis and the manner in which they related to the learners was slightly different from each other. It would appear that a more detailed structure needs to be established for in-depth interviews and interviewers need to have a good understanding of the research focus and its questions so that they may pose them appropriately. The time that the in-depth interview took to be completed was underestimated, even though a 'trial run' had been done with the completion of the pilot study. This could not be controlled since learners could not be curtailed in their responses and the interviewers encouraged discussion in some cases. It would appear that the gist of what was relayed to the interviewer was not affected and that in most cases only more detail was added to what the learners had to say.

The interviewers were requested to reflect on the interview process. Both of them felt that the physical environment could have been more conducive to learners' expressing themselves without disruptions such as the school siren, the noise level outside the interview venue, as well as the cramped quarters. One of the interviewers also felt that there were time constraints that could have influenced the spontaneity of the learners because they could have felt 'rushed'. Both interviewers felt that the learners were honest in their responses to the questions posed with one alluding to 'messages' gained from the body language of the interviewees, the manner in which the questions were phrased and voice intonation of the interviewer (see Appendix M).

As researcher, my involvement with the survey questionnaire as well as with the semi-structured, in-depth interview was one of duplicating the survey questionnaires, organising the venues, providing logistical support, facilitating the attendance of the learners at the interviews and the survey questionnaire and facilitating the management of the process that included collecting the completed survey questionnaires. I did not feel comfortable conducting the in-depth interviews personally because, as principal of the school at that time, my position as an authority figure could have placed constraints on the learners and had an undue influence on their responses. Also, my age and sex could have inhibited their responses.

Chapters Five and Six presents the analysis of the data from the survey questionnaire.

CHAPTER FIVE
Perceptions of and attitudes towards science and science careers

5.1 Introduction

Learners are exposed to science in various ways and in different facets of their lives. This study is focused on learners' perceptions of science where these perceptions are influenced by social dynamics in the home and society at large, including by socio-cultural influences and the media. It is interested in unpacking the effects of these influences on learners' thinking about science, in particular, how gender mediates this thinking and gives effect to actions that portray and perpetuate gender stereotyping in the field, with its concomitant effects.

This chapter is the first of two in which I will be presenting, analysing and discussing the findings of the quantitative study. Chapter Five focuses on learners' interests, activities and exposure to science predominantly in the context of the home. Learners' homes function on applied science in the form of the appliances that may be found in homes today. Their activities involving these appliances portray a level of scientific interest. The chapter first explores the learners' interest in, activities in, and exposure to science in and around the home. The second part of the chapter is an analysis of the impact that society's gender perceptions and stereotyping has on careers in the science field. This section also considers the influence that parents reportedly have on learners' science interests and career aspirations in the field of science.

With regard to the impact of learners' gender on their views of careers in the science field, learners were asked to respond to the role of gender in terms of who participates in science activities, and their perceptions of the influence of race in terms of who are represented in science careers. Learners were also asked to respond to the role of the media in gender stereotyping in science and science careers.

The chapter concludes with the impact that the portrayal of science by the media has on the perceptions of young people about science.

Similar issues in gender and science were investigated in both the in-depth interviews of the qualitative study and the survey questionnaire of the quantitative study.

5.2. Learners' interest in, activities in and exposure to science

Girls' and boys' science interest is shaped by what they regard to be useful in and relevant to their everyday lives, and the prevailing perceptions in society of what is accepted behaviour and practice regarding science interest. One could differentiate between academic science, as in what happens in science classrooms, and the practical science applications that learners experience in their everyday lives. This differentiation points to the challenge for academic science amongst young

people: it needs to become more relevant to their lives at all levels. Academic, school science appears to be too far removed from the everyday lives of girls and boys. One would expect organisation and planning in the formal education system to take cognisance of this so as to influence learners' science interest. The fact that learners' science interest is shaped by their view of what is useful and relevant in their day-to-day lives means that the geographic location and socio-economic strata in which learners live thus become relevant factors that have some bearing on their science interests and activities. According to Christidou (2006), learners' interest in science is not homogeneous: it is based on various, inter-related factors such as the subject, the topic, the specific activity and gender. These factors that influence learners' interest in science are mediated by the context of their lives; their responses to the questions in the survey should be understood in this light.

5.2.1. Interest in science applications: gender and age

Learners' responses were sought about interest in specific, applied science activities. The responses are graphically represented in Figures 5.1 to 5.6 below. The purple bars in the graphs represent responses to the question about how cars and machines work, the burgundy bars to the question about how gadgets like DVD players work, and the yellow bars to the question about how computers work. The graphs in Figures 5.1 and 5.2 indicate that, for the age group 12 to 13 years, whereas Grade 7 girls' interest in how science applications work is waning, the interest of boys in Grade 7 is intensifying. The same trend is noticeable for boys' and girls' interest in Grade 8, in Figures 5.3 and 5.4, and Grade 9, in Figures 5.5 and 5.6. When one looks at the graph for Grade 9s, the sharper gradient of the graph indicates a strong intensification of the interest of the Grade 9 boys. The trend lines indicated on the graphs of the Grades 7, 8 and 9 boys indicate an increase in the gradient. This shows that, as the boys get older, and as they progress in grades, they develop a stronger interest in how science applications work. The downward gradient of the graphs for the girls in all grades is consistent, indicating a sustained intensifying of disinterest from girls in Grades 7 to 9. The indications on the graphs, of an inverted intensity of interest of the boys as compared to girls, are a significant difference: they allude to the socio-cultural effects of socialisation and that the stereotyping of gender roles has become embedded. Boys are 'living out' society's expectations of them as the 'practical' ones who fix things in this 13-year-old to 15-year-old phase of adolescence.

FIGURE 5.1
GIRLS Grade 7: Science interest

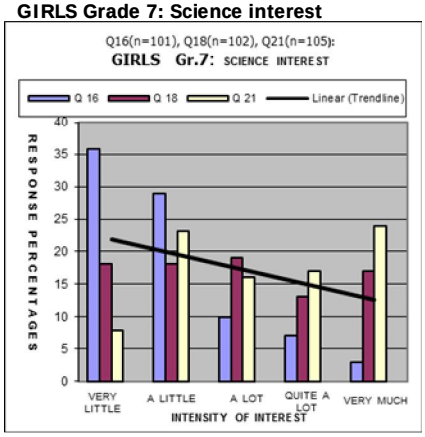


FIGURE 5.2
BOYS Grade 7: Science interest

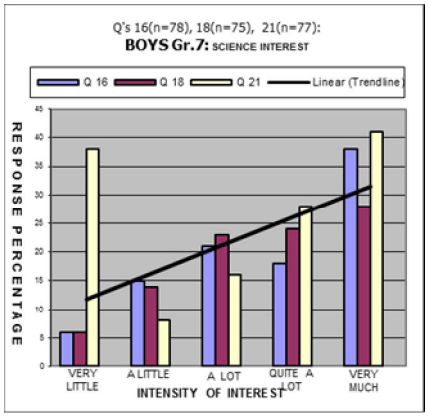


FIGURE 5.3
GIRLS Grade 8: Science interest

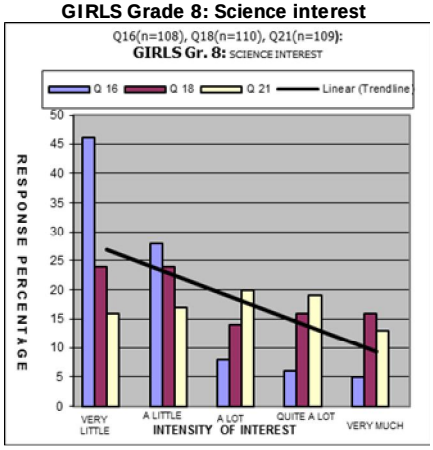


FIGURE 5.4
BOYS Grade 8: Science interest

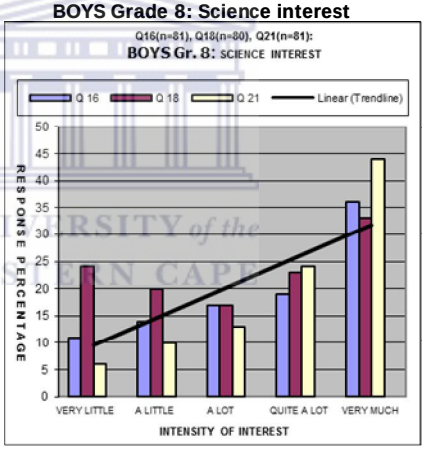
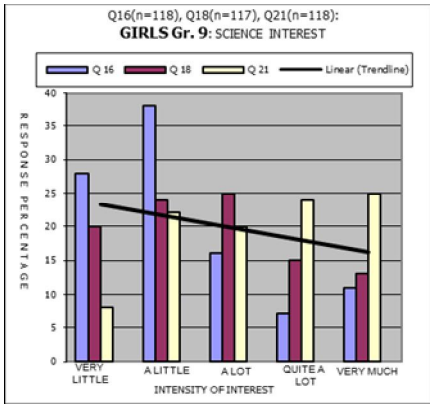


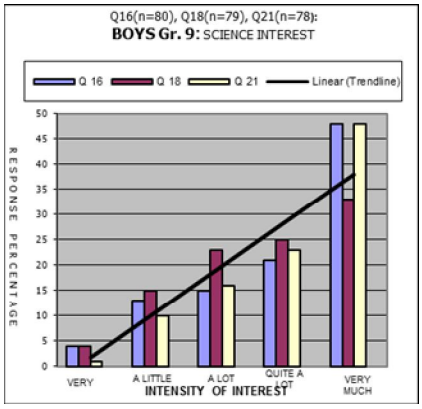
FIGURE 5.5

GIRLS Grade 9: Science interest



.....FIGURE 5.6

BOYS Grade 9: Science interest



The learners' responses to Questions 16, 18 and 21, which referred to how science applications work, were aggregated and a trend line generated. As can be seen from the table below, the responses of the girls to Question 16, for example, in the grey shaded column, whether they were in Grade 7, 8 (especially) or 9, show the same trend of decreasing intensity of interest in science applications:

FIGURE 5.7 **Question 16: What are the things that interest you?: HOW CARS AND MACHINES WORK**

	NUMBER OF RESPONSES OF GIRL AND BOY LEARNERS TO QUESTION 16, PER CATEGORY									
Q.16: HOW CARS AND MACHINES WORK, INTERESTS ME...	1 (VERY LITTLE)		2 (A LITTLE)		3 (A LOT)		4 (QUITE A LOT)		5 (VERY MUCH)	
	GIRLS	BOYS	GIRLS	BOYS	GIRLS	BOYS	GIRLS	BOYS	GIRLS	BOYS
GRADE 7	43	5	35	12	12	17	8	14	3	30
GRADE 8	53	9	33	12	9	14	7	16	6	30
GRADE 9	33	3	45	10	19	12	8	17	13	38

So, according to these indicators of interest in applied science, boys' interest increases as they grow older. It is clear indicated in Figure 5.7 above, it is clear that the girls in Grades 7 through 9 do not appear to be showing a sustained interest in the mechanics and engineering of these science applications. Girls, in contrast to the boys who show an increasing intensification of interest, are exhibiting society's expectations of them as 'steering away' from the practical aspects of 'fixing things', bearing in mind that interest in cars and machines is highly masculinised. Walker, Butland

and Connell (2000, p.5) sum up the connection between boys, cars and masculinity aptly when they state that:

> "More generally, motor vehicles and their use offer boys and youth engaged in the construction of masculinity a number of experiences that many of them very much want: a sense of technical mastery, a realm that is symbolically masculine.... Conceptually we may argue that motor vehicle use has become an arena of domination – both of hegemonic masculinity... and of men over women – in which many young men are able to assert ... a degree of power and authority..."

The data show that, compared to girls, more boys have a strong interest in how machines, cars and computers work, as indicated in their responses in numeric categories four and five. From a different perspective, Figure 5.8 below indicates more blatantly boys' and girls' differing responses to Question 16 about cars and machines:

FIGURE 5.8: **Responses to Question 16: How cars and machines work**

QUESTION 16: HOW CARS AND MACHINES WORK: **SUM OF PERCENTAGE RESPONSES 4 AND 5**: 4: (INTEREST) QUITE A LOT 5: (INTEREST) VERY MUCH		
	% GIRLS	% BOYS
Gr.7	9 (n = 101)	55 (n = 78)
Gr.8	11 (n = 108)	55 (n = 81)
Gr.9	18 (n = 118)	69 (n = 80)

The boys' and girls' responses to the questions that referred to how science applications work correlate strongly with those elicited in the in-depth interviews which reflected learners' views on girls' selecting car mechanics as a career choice, where similar such differences were highlighted. The clear statistical and graphical indications of the responses that are illustrated in Figures 5.1 to 5.8 show a sustained interest on the part of boys in careers that have to do with how science applications work. The responses to the survey questionnaire, as do those in the in-depth interviews, would support the view that boys are of the opinion that being a car mechanic, as a career choice, is more suited to boys than girls. The boys' responses were stronger than the girls': there is a minimum of a 40% difference in the response numbers of the girls and boys as is indicated in Figure 5.8 above that substantiates the assertion that boys are more interested in science applications.

The boys' and girls' responses to Questions 18 and 21, regarding interest in the functioning of DVDs and computers, show the same contrasting trend, although the contrast appears to be less extreme. Whereas boys show an increasing interest as they move from Grades 7 to 9 in how DVD players and computers function, girls are much less interested. The girls' responses are more varied, despite the trend line indicating a waning interest from Grade 7 to Grade 9. The reason for this may be that girls use DVD appliances and computers in their everyday lives, which makes them more a

part of their lived, social reality. With regard to the everyday life experience of girls and boys with cars, their ages would legally limit their use of cars to that of passengers in a mode of transport.

Where science, in its application, has an overtly emotional, compassionate, caring and nurturing feature to it, it could be described as 'affective' science. This is more pertinently the case with sciences that are concerned with the nurturing and caring aspects of health. In order to gauge learners' interest in science, questions were posed that elicited their responses to affective science. In Section Two of the survey questionnaire, which dealt with activities that interest them, learners were asked to indicate their level of interest, on an intensifying, semantically progressive scale, to questions of how mother's milk is produced (Question 17), how medicines heal illnesses (Question 19) and how sick animals are treated (Question 23). Figure 5.9 shows the responses of the learners to the question of how mother's milk is produced:

FIGURE 5.9: **How mother's milk is produced**

QUESTION 17: HOW MOTHER'S MILK IS PRODUCED: **SUM OF PERCENTAGE RESPONSES TO 4 AND 5:** 4: (INTEREST) QUITE A LOT 5: (INTEREST) VERY MUCH		
	% GIRLS	% BOYS
Gr.7	20 (n = 101)	10 (n = 78)
Gr.8	31.8 (n = 108)	10.6 (n = 81)
Gr.9	33.3 (n = 118)	4.9 (n = 80)

The activity 'how mother's milk is produced' has a distinct gender and affective slant in that it has to do with women's physiology and links to caring and nurturing. As the data in Figure 5.9 above indicate, the percentage responses of the Grades 7 (20%), 8 (31.8%) and 9 (33.3%) girls clearly show a stronger response as compared to the boys; the boys show a measure of disinterest, perhaps because they regard the activity to be more of interest to women. By implication, their interest in this activity would be a sign of being caring, a quality that they would attribute to women, which does not fit their masculine image. It is interesting to note that there is a noticeable difference of 13.3% between the percentages of the Grade 7 primary school girls (20%) and the Grade 9 secondary school girls (33.3%). Most Grade 7 girls are at the start of the physical changes related to puberty and are starting to develop attitudes and perceptions about womanhood related to those changes. Grade 9 girls are well into the puberty period of rapid physical development and have a more mature, 'adult' interest in matters relating to women's development. Grade 9 boys are experiencing physical changes associated with dominant manhood and developing attitudes and perceptions that would establish themselves as successful men. The small percentage of Grade 9 boys who showed 'quite a lot' to 'very much' interest, thus creating the largest gender difference in the responses in different grades, points to a strengthening of the stereotyped categorisation of the activity amongst the boys, as one located in the female domain. The biological developmental stage of Grade 9 boys and girls

influences their perceptions of, attitudes to and opinions of activities that appear to be traditionally gender-related. This, together with the doubling, by grade, of the percentage difference between boys and girls, points to a strengthening of the perception of the activity as nurturing and affective. Learners' responses to Questions 16 to 25 adhered, to a large extent, to stereotypical perceptions of interests that would be traditionally associated with specific genders. Gender roles, imposed by societal pressure to conform to gender expectations, appear to have become embedded already at this stage of adolescence.

The survey questionnaire also attempted to establish whether learners' interest in science transformed into actions, like accessing science information, reading science articles, participating in science clubs or entering science competitions. These are actions that develop a mindset toward science and put the learner on a road to selecting Physical Sciences as a subject in the FET Phase, pursuing science in tertiary studies and following a career in science or a science-related field. The overall question is to what extent gender mediates the responses of boys and girls with regard to reporting an interest in and the pursuit of science activities.

5.2.2 Electronic access to science-related activities

The role of computers in providing learners with opportunities to access information about leisure activities, to communicate via email and social networking sites, and to retrieve information, has grown dramatically. Institutions like libraries and schools are increasingly making computers with Internet connectivity available to learners to facilitate this access. The learners' focus of interest in the Internet is established in the survey questionnaire. These questions are connected to the question establishing whether the learner has access to the Internet. Of the learners surveyed for computer access, 68.2% have computers in their homes. That means that learners' potential to access scientific information has improved from a few years ago when computers in learners' homes were almost unheard of. The homes' connectivity to the Internet dramatically improves learners' access to information and their understanding of and participation in the modern world. Internet connectivity is key to enhancing learners' ability to engage with scientific information. The investigation of learner access to computers and the extent to which learners' homes are connected to the Internet attempts to respond to the research question of the degree to which learners' social reality influences their experience with and perceptions of science and science education. Figure 5.10 below presents the statistics of learner households that are connected to the Internet as a percentage of those that have computers:

FIGURE 5.10: **Computer usage and learner households connected to the Internet**

	Grade 7 (n=200)	Grade 8 (n=200)	Grade 9 (n=200)	Average
Percentage of learner homes surveyed that have computers	61,9	72,2	70,4	68,2
Percentage of learner homes with computers that have Internet connectivity	46,4	40,6	37,6	41,5
Percentage of *total* number of learners participating in the survey that have Internet connectivity	28,3	29,2	26,5	28,0

An examination of the data in Figure 5.10 of learners' access to the Internet as compared to computer presence in the home reveals that, on average, 28% of the total number of learners surveyed have access to the Internet. This relatively small percentage reduces the authority, reliability and dependability of assertions regarding the influence of gender on the behaviour of learners in the GET Phase in accessing science-related information via the Internet, and weakens the revealing of any significant trends. However, the data were analysed for trends in computer use by learners in the GET Phase and to ascertain to what extent the computer was being used to access science and science-related Internet sites and information. In this regard, in response to the question that examined what they do most on the computer, the data reveal that an average of 66.4% of the learners with access to computers at home, responded to the three categories "a lot", "quite a lot" and "very much" when asked to respond to the extent of their use of the computer to play computer games. This is in contrast to the average percentage response in the same three categories to the questions that investigate the use of the computer, where there is Internet access, to access science and science activities (and the gender differences, if any, implicit in these responses). These results reveal that a far lower percentage of surveyed learners across the GET Phase who have Internet access are accessing science and science-related activities than are using the computer to play computer games. GET learners regard computers, as evidenced by the above statistics, as more of a leisure tool than one for serious educational activities; unless they see accessing science sites as part of a formal education task that is prescribed by teachers they don't appear to want to use it for that purpose. It could also be that learners' life worlds are limited through lack of exposure to the pursuance, via computer Internet sites, of science activities and science career interests at home. It needs to be pointed out that the costs of Internet access in South Africa are prohibitively high for the households in which learners who participated in this survey live, as well as for the schools which they attend. This brings into focus again the link between socio-economic status and social class on the one hand, and access and exposure to science and science education in homes, as well as in educational institutions, in poor and low-income communities on the other. One needs to consider

the level of exposure that learners have had to interactive communications technology as a consequence of the economic capacity of their parents to provide these tools in the home, as well as the gender differences in this exposure.

5.2.3 Participation in science activities at home

The science activities presented to learners that they participate in at home, represent a mix of pure and biological science activities, and caring and nurturing, 'affective' science activities that ordinarily take place in and around most homes. By including them in the questionnaire and analysing the responses to them, I tried to establish whether the girls' and boys' interest in science translated into involvement in science-related activities. I also tried to establish whether there is a difference in the intensity level of responses of the boys and girls. Questions about fixing a broken cellular phone, connecting the wires of an electric plug, and fixing an electric hairdryer are about the repair of appliances, and are thus related to mechanical-electrical applied science disciplines. The responses to the question about connecting the wires of an electric plug showed that 42.5% to 53% more boys than girls responded positively. The responses of boys and girls to questions about fixing a broken cellular phone and fixing a hairdryer bear no significant difference. Apart from the wiring of an electric plug, which is one of the formal assessment tasks in the GET science syllabus, the activities in Questions 51 and 55 are of a technical skill level that could be out of reach for GET learners.

The purpose of including the question in the questionnaire about helping someone get over the flu was to determine the levels of participation of girls and boys in specific types of science activities and whether this participation showed any gendered trends. The question has an affective science quality in that it contains an aspect of caring and nurturing. From Grades 7 through 9, increasingly more girls responded positively to the question than boys. It is interesting to note that whilst the girls, increasingly from Grades 7 through 9, responded in the affirmative, the response gap of Grade 7 and 9 girls widened from 16.7% (Grade 7) to 52.8% (Grade 9) thus indicating a firm strengthening of the affective feature as the girls got older. It could also indicate, however, that as they got older, girls assumed more responsibility to look after someone who was ill. The boys' percentage responses per category, as well as the gap between affirmative and negative responses, remained more or less constant from Grades 7 through 9. In response to the question about a traditionally feminine activity in the home (baking a cake) the girls' responses were significantly positive, with a difference ranging from 50% in Grade 7 to 34% in Grade 9 between their responses and those of the boys. Spearman's Correlation Coefficient test of the data of the responses to the questions that related to helping someone get over the flu and baking a cake indicates that there is a

perfect correlation of 1 between the responses of the girls and boys across Grades 7 through 9. Just as many boys had *not* assisted someone to get over the flu or baked a cake as girls had assisted someone to get over the flu and had baked a cake. Questions 52, 53 and 54 were rooted in traditionally masculine and feminine activities in the home; the responses bear out the stereotype of 'men doing the fixing' and 'women doing the cooking and caring'. These responses also correlate with responses from the in-depth interviews that reveal learners' stereotypical views of the roles of men and women in the home, further leading to the type of career they should be pursuing. The findings of this research with regard to learners' interest and participation in science activities correlate with those of Christidou (2006, p.1181), who found that:

> "Significant gender differences emerge: girls are more interested in topics related to human biology, health, and fitness, and are more familiar with using instruments and devices, seeking information about nature, and doing cuisine and handicraft: while boys are more interested in science, technology, and their social dimension, and the threatening aspects of science and technology, and tend to engage more in manual work and computer use."

Miller, Blessing and Schwartz (2006), in summarising their research and affirming the gender differences that exist between boys and girls' science interest, add another dimension to the aspects mentioned by Christidou (2006) when they state that:

> "...it appears that females' rejection of science is not related to a perception that it is too hard or not fitting the female gender role; they simply do not find it interesting or relevant to their life goals." (Miller, Blessing and Swartz, 2006, p.377)

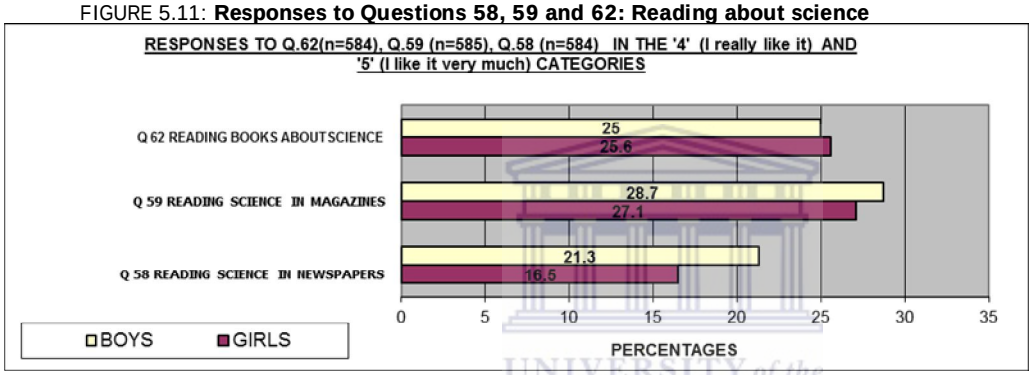
The questions about growing plants from seeds and cleaning up the environment elicited responses from learners to issues concerning nature and the environment. No statistically significant difference was found between the responses of girls and boys to these questions. This may be attributed to the fact that these are activities that are not gender-stereotyped in society but of mutual interest to all, without being gender-polarised in the media. Generally, the responses to questions about participation in science activities in the home subscribe to gender-stereotypical viewpoints of which science activities would suit which gender.

5.2.4 Reading and talking about science

The question is whether learner interest in science is translating into action in the area of science, whether at school or at home. Certain questions were grouped together because learners' responses to them would reflect the level of their interest in science and one would be able to establish whether this interest translated into more academic, intellectual engagement (in the form of reading science articles in the printed and electronic media and also discussing science topics). The questions related to the reading of science in newspapers, magazines and books, and the responses

to these questions vary across all grades and for both genders, from a low of 6% in some categories to a high of 42.5% in other categories. An average of 24% of all girl and boy learners across Grades 7 through 9 responded to questions about the print media in the categories four and five – that they "really like" or "like very much" – reading science articles. The statistics indicate that there is no significant gender difference in the responses of girls' and boys' reading of science articles in newspapers, books or magazines. This means that similarly low percentages of girls and boys are accessing science in the media. A graphical representation depicting the percentage responses follows below in Figure 5.11.

FIGURE 5.11: **Responses to Questions 58, 59 and 62: Reading about science**



The graph indicates that an almost equal percentage (25%) of boys and girls are reading books about science and scientists, 27% of girls and 28% of boys are reading science articles in magazines, and 16% of girls to 21% of boys are reading science articles in newspapers. These percentages are low and point towards the composite effects of a lack of access to resources, a lack of motivation to engage with more academically intellectual pursuits like reading, and challenges in reading ability as a result of possible barriers to learning. The geographic area where the primary schools and secondary school in the research are located is a lower middle class one. The newspapers which are commonly read in the area and are not costly are community newspapers that focus on community news and do not normally carry articles on science. It has already been stated that only 28% of the surveyed learners on average have Internet access. This, coupled with the fact that Internet usage is costly in South Africa, has an impact on access to science sites on the Internet. The socio-economic status of the family once again mediates the access that learners have to the resources that provide access to science and science education information and materials. The number of public libraries in the area is inadequate for the number of learners in Mitchells Plain with its overall population of over a million people. Sui Chu Ho (2010, p.409) highlights the value of

reading in the area of science in her research on the role of the family in promoting learners' scientific literacy, when she points out that:

> "...reading books on scientific discovery, watching, reading or listening to science fictions were found to be highly effective activities for promoting children's science achievement and self-efficacy."

Despite the data illustrated above in Figure 5.11, one has to bear in mind that learners' challenges in reading ability and low learner literacy levels have an impact on access and exposure to, and perceptions of science and science education, and have a far-reaching effect on learning. To put learners' levels of literacy and their impact on perceptions of science and science education into perspective in terms of Questions 58 to 63, the literacy levels of the schools that participated in the survey questionnaire are provided. Learner challenges in literacy skills are evidenced by the results that learners achieved in literacy competency tests that were conducted by the Western Cape Education Department (WCED). These tests were conducted with Grade 3 (2002 and 2004) and Grade 6 (2007) GET learners to establish their literacy levels for the grade. Figure 5.12 indicates the scores that learners achieved in the schools that served as the core of those involved in this research:

FIGURE 5.12 **Western Cape Education Department (WCED) literacy assessment results for Grade 3 in 2002 and 2004 and Grade 6 in 2007**

SCHOOL NAME (Schools' names have been withheld as an ethical measure to protect confidentiality.)	Column A	Column B	Column C
	GRADE 3: % PASS RATE IN 2004	GRADE 6: % PASS RATE IN 2007	GRADE 3: % PASS RATE IN 2002
	THESE ARE THE SAME LEARNERS WHO WERE IN GRADE 7 IN 2008 WHEN THE SURVEY QUESTIONNAIRE WAS CONDUCTED		THESE LEARNERS WERE IN GRADE 9 IN 2008
Primary School 1	35.0	66.7	55.3
Primary School 2	30.0	31.7	72.5
Primary School 3	38.0	47.5	50.0
Primary School 4	DID NOT PARTICIPATE IN TESTING	65.6	70.0
Primary School 5	28.0	53.3	42.5
Primary School 6	28.0	47.7	90.0
Primary School 7	34.0	45.0	46.2
Primary School 8	38.0	48.6	45.0
THE WCED REGARDED 50% AS A PASS FOR THE LITERACY ASSESSMENT.			

The scores of the Grade 3 (2002 and 2004) and Grade 6 (2007) learners were extracted from the results of the WCED literacy assessment competency testing because they bear relevance to the learners who participated in the survey questionnaire for this research. Allowing for drop-out and drop-in rates, migration into and out of schools and provinces, and other dynamics that could affect the composition of the population of learners who initially participated in the assessment, the Grade

3s of 2002 (Column C) would form the bulk of the Grade 9s of 2008. In the same manner, the Grade 3s of 2004 (Column A) would form the bulk of the Grade 7s of 2008 (Column B). The Grade 6 (Column B) literacy assessment test scores of 2007 were extracted, since these learners are from the same cohort who wrote the Grade 3 tests in 2004 and who, as Grade 7s, participated in the survey questionnaire conducted in 2008.

The scores indicate that in 2004, at Grade 3 level (Column A), none of the learners could pass the literacy assessment tests at the 50% pass requirement level. All the schools' learners scored on average, below 40%. Whilst there was some improvement in the literacy levels of these learners when they reached Grade 6 in 2007 (Column B), in five out of the eight schools, less than 50% of each school's learners could attain the pass requirement of 50%.

The Grade 9 learners who participated in the survey questionnaire for this research (Grade 3 in 2002 – Column C) faired somewhat better in the Western Cape Education Department's literacy assessment testing, with only three schools not able to get 50%. The average score of Grade 9 learners (Column C) was 58.9%. The picture that Columns A to C present is that of learners struggling with literacy, specifically the ability to read with comprehension. This connects with the low number of learners reading science-related articles. This begins to answer the question why learners would want to read science articles in the print media if they don't appear to have a love for reading because of challenges that they experience in this domain. Coupled with the popularity of television as a medium where learners can just 'sit back and let images flash past them' without their having to actively interact at an intellectual level, one begins to understand the low levels of engagement with science and science education in the print media. These findings thus resonate with the apparent lack of motivation of learners in Grades 7, 8 and 9 to engage in an intellectual and academic pursuit like talking about science, or reading articles about science in books, magazines or newspapers (see graph in Figure 5.11). The implication here is also that learners face challenges in engaging at the level of reading skill, specifically with regard to scientific terminology, that is required when reading science articles in textbooks and magazines. It needs to be pointed out that the learner cohort of this research emanate from schools situated in middle to lower class neighbourhoods. Their parents have a medium to low income level owing, in part, to their level of formal education (see Figure 4.6). This limits resources in their homes to encourage reading and the learners' exposure to science and science equipment.

Compared to the average percentage of learners reading science in the print media (24.03%), a higher average of 48.2% of learners from Grades 7 through 9 responded that they watched science programmes on television. This could be expected since television is a more popular communication medium with which young people engage, than the print media. With the exception of one learner,

all other learners indicated that they have a television set in the home. It could be expected that when asked about "talking about science to friends", an average percentage of only 24.2% of the learners, across all the grades, responded in the categories four ("really like it") and five ("like it very much"), given the low average percentages of learners engaging with science articles via print media. Learners would less likely be able to talk to friends about science if they do not read science articles or watch science programmes on television to any significant degree. The low percentages for participating in more formal science activities would also be a contributory factor to the low response to "talking about science to friends". The responses to Questions 58 to 63 do not indicate a significant difference between girls and boys. Whilst there is a low response percentage for reading science articles in the print media from all learners, there does not appear to be a distinguishable gendered difference for reading science articles.

5.2.5 Science, society, gender and careers

The influence of gender on learners' opinions of the social context in which science, science education and science careers are practised was investigated. Learners' opinions about the role of gender with regard to science in the workplace, stereotypical expectations in science careers, the popularity and importance of science, and science's role in learners' social interaction, were elicited. Learners' views about the lingering influence of Apartheid on science, science education and science careers were also canvassed. They were requested to respond to statements about the manner in which race intercedes in the 'women and science' debate, taking into account the compounded discrimination of gender and race with which Black women have to contend. The statements in this section of the questionnaire were presented in numerically identified categories of opinions that learners had to select.

5.2.5.1 Gendered perceptions of science careers

Careers in the domain of the sciences and applied sciences have been gender-stereotyped as a result of past practices based on societal norms and values of the time. These stereotypes have persisted, despite social transformation, advances in the women's empowerment movement and legalised gender equity provisions in private and public employment practices. The manner in which gender intercedes in GET learners' perceptions of science, science education and science careers was investigated in the questionnaire. Statements about certain careers that require theoretical scientific knowledge, as well as knowledge of and skills in applied science, were presented to learners as typical of specific genders. They were asked to respond to the statements by selecting from categories of choices. The statements in this section elicited learner responses about the gender of

scientists and science activities; in other words, about gender stereotypes in science. The responses of the learners are represented in Figure 5.13 below:

FIGURE 5.13: **CHI-SQUARED TESTS: Statements 99 and 106, 107, 108, 110**
Grades 7, 8 and 9 learner responses to perceptions regarding science careers
(Girls *n* = 356 Boys *n* = 244)

STATEMENT NUMBER	GENDER	WOMEN	MEN	WOMEN AND MEN EQUALLY	CHI-SQUARE	SIGNIFICANT DIFFERENCE (Y / N) CRITICAL VALUE = 5.9	FAVOURED
99. ***Which doctors do you think are better - women or men doctors?***	ALL Girls	68	33	254	8.4	Y: 5%	
	ALL Boys	38	41	160			
STATEMENT NUMBER	**GENDER**	**AGREE**	**DISAGREE**		**CHI-SQUARE**	**SIGNIFICANT DIFFERENCE (Y /N) CRITICAL VALUE = 7.8**	**FAVOURED**
106. ***It is a boy's job to help his father fix machines around the house.***	ALL Girls	185	170		33.6	Y: 1%	
	ALL Boys	181	59				
107. ***If I was visiting the ESKOM nuclear power station, I expect the manager to whom I would be introduced, to be a MAN.***	ALL Girls	148	207		22.9	Y: 1%	
	ALL Boys	141	99				
108. ***Only men should be put in control of driving trains.***	ALL Girls	114	241		8.1	Y: 5%	
	ALL Boys	89	151				
110. ***Men are better rocket scientists than women.***	ALL Girls	162	193		22.7	Y: 1%	
	ALL Boys	149	91				

An analysis of the data in Figure 5.13 reveals that there is a statistically significant difference between the responses of girls and boys to the statements related to the perceptions of the gender of individuals participating in the identified science activities. In Statement 99, learners' opinions were sought as to which gender they thought were better doctors: a larger percentage of the boys (17.2%) than girls (9.3%) felt that men were better doctors than women. This indication was further strengthened by the lower percentage of boys' opinions that women and men were 'equally good' when compared with those of the girls. Slightly more girls (19.2%) than boys (15.9%) felt that women were better doctors. Boys and girls thus favoured their own gender in their responses as to which gender was the better doctor. In their identification of the opposite gender as better doctors, a larger percentage of boys (15.9%) are of the opinion that women are better doctors than girls who are of the opinion that men are better doctors (9.3%). This detail could be related to the fact that the healing aspect of the work of being a doctor is an affective quality and there is evidence in this research, both in the responses to the questionnaire and in the in-depth interviews, that, where

science activities of an affective nature are concerned, the favoured opinion is that women are more suited to the activity than men. A majority of more than two thirds of boys and girls were of the opinion that women and men equally were good doctors, an indication that the majority of surveyed learners didn't conform to the stereotypical view of scientists.

Certain statements required learners to respond to a stereotyped view of science-related careers and pursuits like fixing things around the house, and to science-related careers that require an engineering qualification, such as managing a nuclear power station, being a rocket scientist and driving trains. Statistical analysis revealed that there are significant differences in the responses of the boys and girls. Figure 5.14 below indicates the extent of the difference:

FIGURE 5.14: **Statements 106, 107, 108 and 110: Response percentages**

STATEMENT NUMBER	GENDER	% AGREE	% DISAGREE
106. ***It is a boy's job to help his father fix machines around the house.***	ALL Girls	53.1	47.9
	ALL Boys	75.4	24.6
107. ***If I was visiting the ESKOM nuclear power station, I expect the manager to whom I would be introduced, to be a MAN.***	ALL Girls	41.7	58.3
	ALL Boys	58.8	41.2
108. ***Only men should be put in control of driving trains.***	ALL Girls	32.1	67.9
	ALL Boys	37.1	62.9
110. ***Men are better rocket scientists than women.***	ALL Girls	45.6	54.4
	ALL Boys	62.1	37.9

The significant difference, as indicated in Figure 5.14 is at the 1% level for Statements 106, 107 and 110. This means that the researcher can, with 99% confidence, accept that there is a significant difference in the responses; in all three statements the percentage of boys agreeing was larger than the percentage of girls. The analysis of the response data of all four statements reveals that boys are more in agreement with the stereotypical views of the careers and girls were more in disagreement. This indicates that boys are affirming the stereotypical view of the statements that suggest that science careers are for men, whereas girls are less supportive of and resistant to the stereotypical perceptions. The difference between the responses of girls and boys is more marked for responses to Statements 106, 107 and 110 than for Statement 108. In Statement 108, the researcher can with 95% confidence state that there is a difference in the responses, although this difference is smaller, probably because not many learners know that it requires an engineering qualification to drive a train. In Statement 108, the researcher can with 95% confidence state that there is a difference in

the responses of those learners agreeing and disagreeing. Responses to Statement 108 revealed that there is no significant difference between the views of the boys and the girls. 67.9% of the girls disagreed with the statement and a large percentage of boys (62.9%). Whilst it appears that both genders disagree with the statement, most likely because it is commonplace to see women driving vehicles, it would appear that boys are still holding on to the general, stereotypical gender role perceptions that science careers are largely a male domain.

Learner differences in gender-stereotyped perceptions of science careers as they move from the primary school Grade 7 to the secondary school Grades 8 and 9 were investigated further. This closer investigation of the statistics is presented in Figure 5.15 below:

FIGURE 5.15: **CHI-SQUARED TESTS: Statements 106, 107, 108 and 110 Grades 7, 8 and 9 learner responses to perceptions regarding scientists (Girls Grade 7: n = 119 ; Boys Grade 7: n = 80 ; Girls Grade 9: n = 120; Boys Grade 9: n = 80)**

STATEMENT NUMBER	GENDER	GRADE	AGREE	DISAGREE	CHI-SQUARE	SIGNIFICANT DIFFERENCE (Y / N) CRITICAL VALUE =7.8	FAVOURED
106. ***It is a boy's job to help his father fix machines around the house.***	GIRLS	7	67	53	13.8	Y: 1%	
		9	47	73			
	BOYS	7	66	14	7.4	N	
		9	50	27			
107. ***If I was visiting the ESKOM nuclear power station, I expect the manager to whom I would be introduced, to be a MAN.***	GIRLS	7	59	61	17.1	Y: 1%	
		9	34	86			
	BOYS	7	62	18	16.5	Y: 1%	
		9	36	41			
108. ***Only men should be put in control of driving trains.***	GIRLS	7	43	77	11.7	Y: 1%	
		9	22	98			
	BOYS	7	36	44	9.9	Y: 5%	
		9	23	54			
109. ***Women are better at looking after sick people than men.***	GIRLS	7	73	47	12.0	Y: 1%	
		9	52	68			
	BOYS	7	56	23	7.6	N	
		9	39	38			
110. ***Men are better rocket scientists than women.***	GIRLS	7	63	57	7.5	N	
		9	49	71			
	BOYS	7	59	21	9.9	Y: 1%	
		9	40	37			

The statistical analysis of the statement that "it is a boy's job to help his father fix machines around the house" reveals a significant difference between the responses of the Grade 7 and Grade 9 girls. Responding to this statement (that it is a boy's job to help his father fix machines), the girls in Grade 9 disagree (60.8%) slightly more than the girls in Grade 7 agree (56.3%). The Grade 7 girls in the primary school are thus slightly more affirming of the gender-stereotypical view of the science activity than the Grade 9 girls in the secondary school. There are various factors that could have contributed to this. Grade 9 girls are likely to be more receptive to the message of women's empowerment; at their age they would have matured in their thinking about gender more than Grade

7 girls or teachers could have made them more aware of gender issues. Boys in both Grades 7 (82.5%) and 9 (62.5%) strongly agree that “it is a boy’s job to help his father fix machines”, although there is an erosion from the Grade 7 to the Grade 9 boys. Like the Grade 9 girls, the Grade 9 boys would have matured in their thinking a little more, also because of their experience in the more mature climate of the secondary school culture. There is thus a stronger agreement from the Grade 7 boys in the primary school to the statement that helping a father to fix machines in and around the house is a boy’s job. The selections made by the Grade 7 and 9 learners confirm the stereotypical view that boys should be fixing machines around the house, with the boys’ view being more rooted in the gender stereotype than the girls’. The purposeful affirmation of the gender stereotype in the statement, through the unobtrusive identification of the father as the one to fix machines around the house, already embeds the gender stereotype into the statement; the boys’ stronger agreement in both Grades 7 and 9 accentuates the affirmation of the stereotype. In the same vein, the girls’ stronger disagreement than the boys’ accentuates their attitudes to the stereotype that was embedded in the manner in which the statement was presented to the learners.

In response to the statement regarding the managing of a nuclear power station, there is an almost even split between the Grade 7 girls as to those who agree (49%) and disagree (51%) with the statement. A larger percentage of the Grade 9 girls (71.6%) disagree with the statement as compared to the Grade 7 girls (51%). There is thus a significant difference in the gender perceptions of the Grades 7 and 9 girls about whom they would expect to manage a nuclear power station, an indication that with age and life experience there is a weakening of the stereotype amongst the girls, pointing to a resistance to stereotyping of science careers. As in the statement about it being “a boy’s job to help his father to fix things around the house”, Grade 9 girls are showing a maturity in their opinions in that they are moving away from the gender-stereotypical expectations. There is also a significant difference between the responses of the girls and the boys for the statement regarding whom they would expect should manage a nuclear power station. As for the girls, a similar weakening of the stereotype amongst the boys from Grades 7 to 9 is evident in the analysis of the data, although the statistics for the Grade 9 boys who agree and those who disagree are close, once again indicating a general move away from the stereotypical presentation of the science career.

There is a statistically significant difference between the response categories selected by the girls and boys and between Grades 7 and 9 learners to the statement that “only men should be put in control of driving trains”. The responses from both boys and girls across Grades 7 and 9 exhibit a strong disagreement with the statement, with the Grade 9 boys markedly stronger in their disagreement than the Grade 7 boys. This pattern of disagreement with the statement is repeated in the responses of the Grades 7 and 9 girls.

There is a statement in the survey questionnaire that asserts that “men are better rocket scientists than women”. The response of the Grade 7 girls to this statement indicates only a small difference between those who agree (52.9%) and those who disagree (47.1%). In contrast to the Grade 7 girls, the statistics regarding the responses of Grade 9 girls indicate a firm disagreeing with the statement (59.2%), which points once again to the weakening of the stereotype as girl learners progress from the primary to the secondary school. There is a statistically significant difference between the Grades 7 and 9 boys’ responses to the statement that “men are better rocket scientists than women”: there is stronger agreement with the statement from the Grade 7 boys (73.8%) than the Grade 9 boys (50%). This falls in line with the trend of the weakening of gender-stereotypical perceptions from the primary school Grade 7 to the secondary school Grade 9 amongst both girls and boys. This occurs as social reality, life experience, the academic learning progress, the influence of the women’s empowerment message, formal government gender equity messages and aging and maturing in years start to influence understanding and change gender perceptions.

5.2.5.2 Learners’ perceptions of the race and gender composition of science careers

Comment [LG2]: note to self – why not numbered?

Learners have gendered, stereotyped perceptions of careers in the science field. In South Africa, the socio-economic context in which science careers are practiced is influenced by the lingering effects of the system of Apartheid, which limited entry into science careers in a job classification system based on race and ethnicity. The residual effects of the Apartheid system on the psyche of communities mean not only that the images of Whites monopolising certain science careers persist, but also that they still largely occupy those careers. During the Apartheid years, Black women faced added obstacles in their attempts to enter science careers: some science careers, especially in the formal government sector, were closed to any but people classified as ‘White’. It is within this context and against this background that statements were posed in the survey questionnaire and grouped here for comment in order to establish the extent of the lingering effects of Apartheid’s racial job classification, compounded by gender stereotyping, on perceptions of who occupied science careers. These statements and the analyses of them are also in response to the research question that was posed: What role does race play in learners’ reported perceptions of science careers? By implication, this perception would also include stereotypes of science careers. Figure 5.16 below presents the data of learner responses to statements designed to assess the double effects of race and gender on science careers.

FIGURE 5.16: **CHI-SQUARED TESTS:**
Grades 7, 8 and 9 learner responses to racial and gender perceptions of science careers
(Girls *n* = 356, Boys *n* = 244)

STATEMENT NUMBER	GENDER	WHITE WOMAN	WHITE MAN	WHITE MAN AND WHITE WOMAN	CHI-SQUARE	SIGNIFICANT DIFFERENCE (Y / N) CRITICAL VALUE = 5.9	FAVOURED
131. ***In films, I expect the role of a scientist to be played by a...***	ALL Girls	37	87	224	4.2	N	
	ALL Boys	17	75	146			
STATEMENT NUMBER	**GENDER**	**AGREE**		**DISAGREE**	**CHI-SQUARE**	**SIGNIFICANT DIFFERENCE (Y / N) CRITICAL VALUE = 7.8**	**FAVOURED**
119. ***When I visit the hospital I expect the doctor to be a White man rather than a Black African man.***	ALL Girls	60		293	7.7	N	
	ALL Boys	51		189			
120. ***When I visit the hospital I expect the doctor to be a White man rather than a Coloured man.***	ALL Girls	41		313	8.8	Y: 5%	
	ALL Boys	41		198			
122. ***When I visit the hospital I expect the nurse to be a Coloured/Black African woman rather than a Coloured/Black African man.***	ALL Girls	92		262	1.8	N	
	ALL Boys	67		173			
123. ***When my mother and father were young, I think that medical doctors were mostly White men rather than Coloured/Black African men.***	ALL Girls	262		87	1.9	N	
	ALL Boys	188		50			
124. ***When my mother and father were young, I think that medical doctors were mostly White men rather than White women.***	ALL Girls	199		148	2.4	N	
	ALL Boys	150		86			

In the statement that required responses from learners about the gender of scientists in films, the race of the individuals was kept constant whilst the gender differed. 62.9% of the girls and 59.8% of the boys responded that they expected both men and women in the role. In retrospect, in considering the composing of the survey questionnaire and in reference to this specific statement, whilst the race was kept constant, learners could have been given a 'race-neutral' choice to evaluate the extent of their expectation that the race of the person occupying the science career would have been White.

Whilst Statements 119 and 120 presented the learner with a choice between a White man and men of other race groups, the gender of the doctor was presented as male and therefore the stereotype was embedded in the statement. In the statement that presented a choice between a

White and Black man, there was a significantly stronger disagreement in all grades (80.33%) that the doctor would be a White male, which indicates that teenagers' perceptions regarding racial stereotyping do not appear to be linked to the Apartheid practices of the past as they pertain to careers in the medical science field. These teenagers show little or no institutional knowledge of Apartheid practices pertaining to the Industrial Colour Bar as it affected employment practices. Slightly more girls (82.3%) than boys (77.4%) disagreed with the statement, another indication that girls have progressed further along the line moving away from stereotyping careers than boys have. There is a shift in perceptions from the situation during Apartheid (when most medical doctors could have been expected to be White) to one where young people today largely expect to encounter doctors from other races when they visit the hospital. This is also an indication that learners are experiencing the practical outcome of the democratisation of careers to include all race groups. Learners' life experiences have spawned a break with the past as regards racial stereotyping in careers in the medical science field but this break is not as pronounced as the break with gender stereotyping. To place this phenomenon in context, one also needs to bear in mind that the learners participating in the survey questionnaire are 16 years and younger. The eldest amongst them were born just a year before democratic elections took place in South Africa. Aside from living in geographical areas that are racialised spaces and by implication being affected by the racially based policies of the Apartheid government, most of the learners experienced no other institutionalised, formal discriminatory Apartheid practices.

There is a statistically significant difference between the responses of the girls and the boys to the statement regarding the race of the male medical doctor. In comparing responses to Statements 119 and 120, when the expecatations of the racial label was changed from Coloured as opposed to White, there was an even stronger disagreement from both girls and boys. In Statement 120, when the racial label was changed to a Coloured man as opposed to a White man, there was an even stronger disagreement from both girls and boys compared to Statement 119. This could imply that learners would expect a Coloured man rather than a Black African man to be the doctor. Since most of the learners participating in the survey questionnaire are regarded as Coloured, one could expect that they would expect to see a Coloured medical doctor rather than a White one. As is the case in the data relating to Statement 119, slightly more girls (87.9%) than boys (81.1%) disagreed with the statement, once again indicating a progressive move away from stereotyping by girls as compared with the boys. A closer investigation of racial and gender nuances needs to be done with regard to the previous comment.

In the survey questionnaire, learners were also presented with a choice of gender for the career where the race of the individual was kept constant. Girl (73.6%) and boy (70.9%) learners

both largely disagreed with the statement indicating a woman rather than a man being a nurse, showing that the perception that nurses are expected to be women has changed. Responses to the statement with regard to the gender of a nurse show no statistically significant differences between girls and boys, indicating change across gender of this perception.

Learners were expected to select categories of responses about the perceived racial configuration of medical personnel in the past by relating to a situation that they think occurred in their parents' time. These statements are an attempt to establish whether there has been a change in the perception of the racial composition of medical personnel from the learners' parents' generations and themselves. Girls (73.6%) and boys (70.2%) strongly agreed that medical doctors were mostly White men rather than Coloured or Black African men in their parents' time. With the gender in the comparisons being kept constant, the emphasis was on race: there was a clear change in the perception of what the race of the medical officer is now and was then. There was also agreement, albeit statistically less strong, from the boys (61.5%) and girls (55.9%) with the statement that doctors in their parents' time were White men rather than women. The emphasis in the statement was thus focused on gender rather than race. Learners' responses indicate a perception that, in their parents' generation, men occupied these professions rather than women, in a sense confirming the existence of the stereotype through the generations from parent to child. Statistics for learner responses about the race of medical personnel in their parents' time appear to indicate that learners perceived a change in the race of individuals in medical careers. It is clear that perceptions of race as a factor in who occupies careers is still prevalent in the thinking of learners, although there is a clear indication that 'things have changed' from the time of their parents. Once again, this confirms that interventions in the private and public sectors on the racial composition of occupations are having an effect.

An analysis was also completed of the statistics of statements pertaining to the racial profiling of science careers for the Grades 7 and 9 girls and boys to establish whether there is any gender and grade difference in the opinions of primary school Grade 7 girls and boys and secondary school Grade 9 girls and boys. The data are presented in Figure 5.17 below:

FIGURE 5.17: **CHI-SQUARED TESTS:**
Grade 7 and 9 learner responses to racial and gender perceptions of science careers (Grade 9 Girls n = 120; Grade 7 Girls n = 119; Grade 9 Boys n = 80; Grade 7 Boys n 80)

STATEMENT NUMBER	GENDER	GRADE	WHITE WOMAN	WHITE MAN	WHITE MAN AND WHITE WOMAN	CHI-SQUARE	SIGNIFICANT DIFFERENCE (Y / N) CRITICAL VALUE = 5.9	FAVOURED
131. In films, I expect the role of a scientist to be played by a...	Girls	7	9	26	81	3.2	N	
		9	15	34	71			
	Boys	7	6	30	42	1.4	N	
		9	7	23	48			

STATEMENT NUMBER	GENDER	GRADE	AGREE	DISAGREE	CHI-SQUARE	SIGNIFICANT DIFFERENCE (Y / N) CRITICAL VALUE = 7.8	FAVOURED
119. When I visit the hospital I expect the doctor to be a White man rather than a Black African man.	GIRLS	Grade 7	51	27	1.1	N	
		Grade 9	44	32			
	BOYS	Grade 7	21	59	3.1	N	
		Grade 9	14	63			
120. When I visit the hospital I expect the doctor to be a White man rather than a Coloured man.	GIRLS	Grade 7	11	107	4.1	N	
		Grade 9	11	109			
	BOYS	Grade 7	15	65	3.0	N	
		Grade 9	12	65			
122. When I visit the hospital I expect the nurse to be a Coloured/Black African woman rather than a Coloured/Black African man.	GIRLS	Grade 7	33	85	8.5	Y: 5%	
		Grade 9	19	101			
	BOYS	Grade 7	26	54	2.5	N	
		Grade 9	18	59			
123. When my mother and father were young, I think that medical doctors were mostly White men rather than Coloured/Black African men.	GIRLS	Grade 7	86	30	0.5	N	
		Grade 9	90	29			
	BOYS	Grade 7	65	13	5.4	N	
		Grade 9	56	21			
124. When my mother and father were young, I think that medical doctors were mostly White men rather than White women.	GIRLS	Grade 7	59	56	1.3	N	
		Grade 9	68	50			
	BOYS	Grade 7	51	27	1.1	N	
		Grade 9	44	32			

With the exception of Statement 122, the analysis of the statistics for statements in which the racial profile of the career was indicated do not reveal any significant differences between perceptions of boys and girls as they progress from the primary to the secondary school. In Statement 122 there is a statistically significant difference in the data for Grades 9 and 7 girls. The girls from both grades disagree strongly that they "expect the nurse to be a Coloured/Black African

woman rather than a Coloured/Black African man". However, the Grade 9 girls disagree more vehemently than the Grade 7 girls. It appears that the learners' perceptions did not change as they progressed from Grade 7 to Grade 9 as they developed in the adolescent phase and progressed from primary to secondary school.

The response to the research statement relating to the role of race in influencing GET learners' perceptions of science and science education indicates that, whilst the effects of Apartheid on perceptions appear to have waned, there are still residual perceptions that exist. The legal termination of Apartheid and its resultant fading away in the social reality and experience of GET learners' lives diminishes it as a point of reference in their perceptions of science and science education. All that remains is their connection to it via the lives and narratives of their parents and the residual effects that should disappear with time.

When race is removed from the science career profile and we are left with just the gender of the person, learner responses would indicate the degree of stereotyping. Statement 121 required learners to respond in terms of what they expect the gender of a doctor to be when visiting a hospital. A chi-squared test for two independent groups of boys and girls reflected in Figure 5.18 below, revealed that the null hypothesis that there would be no statistical difference between girls' and boys' expectations, could be rejected at the 1% level. That meant that one could assert, with a 99% level of confidence, that there is a significant difference between girls' and boys' expectations of the gender of a doctor when they visit the hospital.

FIGURE 5.18
Statement 121: When I visit the hospital, I expect the doctor to be a man rather than a woman.

RESPONSES		GIRLS %'s	BOYS %'s
Disagree	Grade 7	86.7	68.8
% Difference between girls and boys		17.9	
Disagree	Grade 9	85.9	77.5
% Difference between girls and boys		8.4	

The girls disagree statistically more vehemently than the boys that the doctor would be a man. Whilst, in the in-depth interviews, boys and girls proffered stereotypical reasons as to why there appear to be more male than female doctors, the responses to Statement 121 reveal that there could be other reasons, especially related to girls' reproductive physiology, why girls don't expect to see male medical doctors more than female doctors when they visit the hospital. The statistics also indicate that the difference in disagreement between girls and boys wanes from Grades 7 to 9, indicating that the stereotypical perception appears to be stronger in the Grade 7 boys and that, as boys develop in the adolescent phase, they appear to be moving away from the stereotypical

expectation of medical doctors' being mostly males and moving closer to the girls' perceptions, similarly resisting the stereotypical gender role.

5.2.5.3 Learners and science careers: reported parental aspirations

Before the girl child goes to school, her primary socialisation in socio-cultural interaction in the family has primed her and made her receptive to the messages confirming the male image of science to which she is further exposed in school. Parents, through their relationship with their children, transfer to them their perceptions of who should do what kind of science.

The larger societal institutions, like the family and formal education institutions, reflect society's values and influence parents' aspirations for their children's careers. Parents articulate the views of society as a reference for their children in the norms and values that they associate with particular careers and are likely to promote these norms and values in their socialisation practices. Their preferences of the careers they would like their children to pursue reflect these norms and values. The powerful and influential role that parents have on their children's career aspirations is pertinently described by Miller, Blessing and Swartz (2006, p.377) in their comment that:

> "People in power who have control over girls' lives, such as science leaders, educators, law-makers, and parents, have perceptions of gender roles and of the nature of science practices that lead to social structures and socialization practices that greatly influence girls' experiences and thus their perceptions, interests, and career plans regarding science."

Parents' reported influence on their children's career choice made up the focus of Questions 68 and 69. Specified career choices, although randomly selected so as not to lead respondents on, could be categorised as science-related and non-science-related in the following manner, as shown in Figure 5.19:

FIGURE 5.19: **Science-related and non-science-related careers**

SCIENCE-RELATED CAREERS	NON-SCIENCE-RELATED CAREERS
Help in healing sick people	Teach children how to read and write
Fix electrical gadgets like computers	Sell products to customers
Look after sick people	Become a professional sportsperson
Fix mechanical or electrical problems on cars	Help people solve their problems like getting their pension
	Manage a shop

FIGURE 5.20
Fathers' career choices for their children

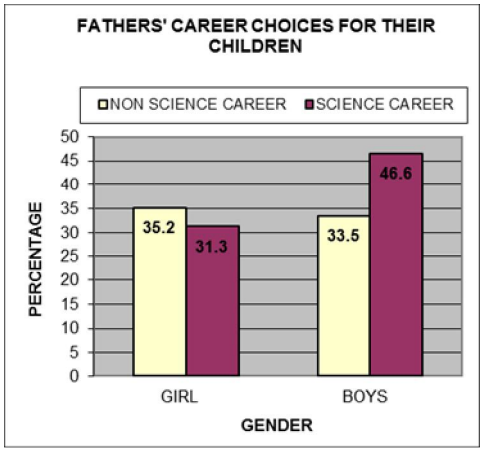
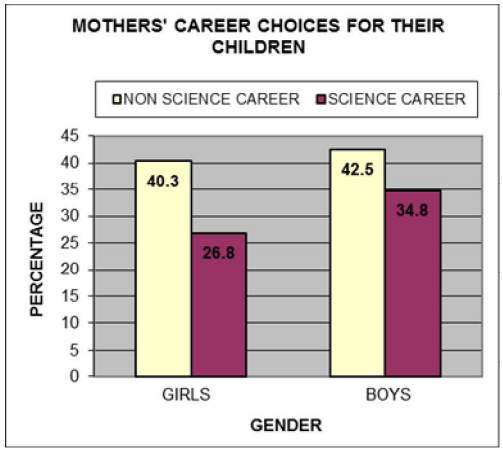
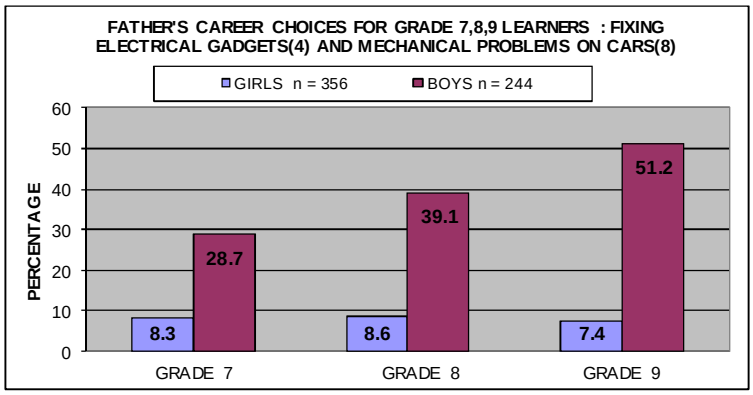


FIGURE 5.21
Mothers' career choices for their children



The percentages of girls' and boys' responses were aggregated. Whilst there appear to be no significant statistical differences in what career mothers and fathers, according to their children, would want their Grades 7 to 9 children to follow, clearly, the choices are not similar. According to learners, their fathers appear to want their boys more than their girls to follow a science career, and fewer boys than girls to follow a non-science career, than their mothers would. The non-science choices appear to be stronger from mothers than fathers for girls but especially so for boys. By learner accounts, fathers and mothers are thus maintaining gendered stereotypes by expecting their boys and girls to aspire to gender-oriented careers. This is an aspect of socialisation which shows how stereotypes are set and promoted in society by one of the more powerful influences on learners, their parents. A closer look at the data for careers in mechanics and fixing electrical appliances that were also used to elicit responses regarding interest in science and in the in-depth interviews, showed a similar pattern of responses, as depicted in the following graph:

FIGURE 5.22: **Fathers' career choices for Grades 7, 8, and 9 learners: Fixing electrical gadgets (4) and mechanical problems on cars (8)**



The gender stereotyping of these careers appears to persist amongst learners and their parents and more so for boys and their fathers. The statistics of this research suggest that the closer one gets to the more 'hard core' science careers such as mechanical engineering, the stronger the stereotyped perceptions of the careers become, especially amongst males.

FIGURE 5.23 **Parents' employment**

Parents' **employment sector**	Non-science jobs %	Science jobs %
Mothers	92.7	7.3
Fathers	90.2	9.8

The question is what the employment background of the parents is. Figure 5.23 above indicates that parents are employed mostly in the non-science sector. A comparison with the data in Figures 5.20, 5.21 and 5.22 that show the careers that parents would want their children to pursue, indicates that whilst fathers are not themselves employed in the science sector they would want their boys especially to pursue science careers. Mothers, on the other hand, who are mostly employed in the non-science sector, want their girls and boys to follow non-science careers predominantly. This trend of fathers' favouring boys to pursue science careers underscores the male persistence in maintaining the gendered stereotype of the male-dominated image of science and of science's being a male domain.

5.2.5.4 Learners and science careers: impact of the media

The popular media, comprising television, film, newspapers and magazines, play an important role in formulating and informing learner opinions about science, scientists and science careers. Through the media, messages are communicated to learners and their opinions are influenced regarding the role that gender plays in science. The impact of the media on learners' views on gender, science and science education was investigated in this section of the survey questionnaire.

Studies indicate that the media image of a scientist as a White male persists and Finson (2002, p.341) points out that "even most minority students draw images of Caucasian scientists". The effect of the media's representation in television and films of science and scientists on learners' perceptions of scientists and science activities was gathered through their responses to statements in the survey questionnaire. The responses indicate that, as a group, both girl and boy learners expect a scientist to be portrayed either as a man or a woman although both boy and girl respondents, faced with the choice of deciding whether the role of a scientist would more likely be portrayed by a male or a female, favour the view that it would more likely be a male, as indicated in Figures 5.24, 5.25 and 5.26. The graphs in Figures 5.24 to 5.26 below show a similar pattern of learner responses to statements regarding the representation of scientists on television, in film and particularly in science fiction films, for Grades 7 through 9 for boys and girls. There are no statistically significant grounds for asserting that girls and boys differ significantly in their responses to the statement relating to the gender of the person that in television programmes they would expect to play the role of a scientist; their expectations of the gender of scientists does not differ significantly when they watch a television programme where a scientist is involved.

FIGURE 5.24
All grades' responses to Q 125: Gender of role of scientist in film and on TV

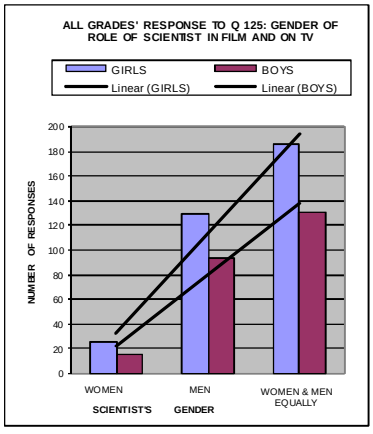


FIGURE 5.25
All grades' responses to Q 126: Gender of role of scientist in films

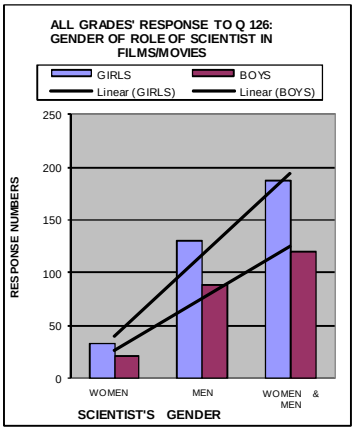
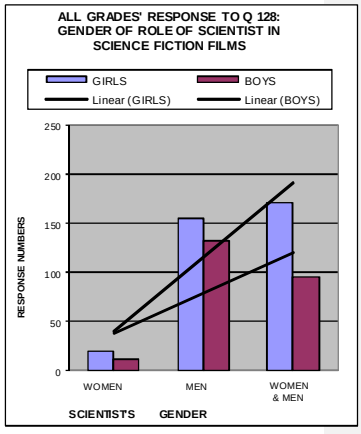


FIGURE 5.26
All grades' responses to Q 128: Gender of role of scientist in science fiction films



It would appear that both girls and boys expect to see both men and women playing the roles of scientists on television or in films, although learners' expectations of the extent of either men's or women's appearance in these roles were not investigated. There is a connection between learner responses to statements regarding the gender of scientists on television and in film and their responses to the statement about the gender of doctors they would encounter in a hospital. A statistical analysis of responses to this statement (see Figure 5.18) indicates that there is a significant difference between what Grades 7 and 9 girls and boys expect the gender of a doctor in a hospital to be. Whilst both girls and boys disagree that it would be a man rather than a woman, the girls disagree more vehemently. However, I found that in the in-depth interviews, when girls and boys were asked what gender they would expect a scientist in a film to have, all the boys and ten out of fourteen girls responded that they expected the roles of scientists in films to be portrayed by men rather than women. There is a need to investigate girls' and boys' understanding of the semantics of what a 'doctor' and a 'scientist' are, since it would appear that their understanding of the two career labels' differs; they don't understand that a 'doctor' is also a scientist. It could also be that, because of their lived, social reality, boys and girls have differing expectations of what the gender of the doctor they would encounter in hospital would be. Because of their experiential contact with a 'scientist', according to their understanding of the term, in television programmes or films, they appear to have an equal expectation that the scientist would be either male or female.

The statistics for those learners who gave a single gender response to the statements about the gender of a scientist indicate that there is also no significant difference between boy and girl learner responses. When faced with a choice between a man's or a woman's portraying the role of a scientist, they expect that a man rather than a woman will fulfill the role, as indicated in Figures 5.21, 5.22 and 5.23. However, in all three grades, most of the respondents selected the category that indicates that, in films or on television, they had an equal expectation that a man or a woman would portray the role of a scientist. The statistics for all learners do, however, indicate that the expectation for women exclusively to play the role, is least expected. Faced with a choice of gender, there is thus a clear bias against women portraying the role of a scientist exclusively, as compared to men portraying the role exclusively, yet there is also support for the view that they both play these roles. Statistical testing of the data relating to Statements 125, 126 and 128 is tabulated below.

FIGURE 5.27: **CHI-SQUARED TESTS: Statements 125, 126 and 128: Learners' gender expectations of role of scientists in television and on film**

STATEMENTS	CHI-SQUARED TEST STATISTIC			SIGNIFICANT DIFFERENCE (Y / N) CRITICAL VALUE = 5.9	REMARKS
	GRADE 7: BOYS AND GIRLS (n = 195)	GRADE 8: BOYS AND GIRLS (n = 197)	GRADE 9: BOYS AND GIRLS (n = 198)		
125 Scientists' gender on television	2.5666	1.2191	2.3372	N	**NULL HYPOTHESIS MAY NOT BE REJECTED**: There is no significant difference between boys' and girls' expectations of the gender of scientists in film and on television.
126 Scientists' gender in films	.7665	.5195	1.8333		
128 Scientists' gender in sci-fi films	4.6956	3.041	5.3888		

Learner engagement with science via visual media like the Internet, television, film and print media like magazines and newspapers forms an important aspect of this research in its attempt to establish their perceptions of science and scientists and how gender intercedes in these perceptions. It is apparent from statistics of statements that elicited learner responses to their level of reading about science that they don't read much about science. It does appear, however, from the responses to Statement 60, that they watch more science programmes on television. That may be since, because of its ease of access, television is a popular medium in society. Learners were asked to respond to statements about the gender of the person on television or in popular magazines who would most likely be portrayed as the person looking after sick people. The result of a chi-squared Test indicates that one could state, with 95% confidence, that there is no significant difference between the responses of girl and boy learners. The results are tabulated in Figure 5.28 below:

FIGURE 5.28: **CHI-SQUARED TEST: Statements 127 and 129 Grades 7, 8 and 9 learner responses to expectations of the gender of the person who has the role of looking after sick children (Girls *n* = 356, Boys *n* = 244)**

STATEMENT NUMBER	LEARNER GENDER	WOMEN	MEN	WOMEN AND MEN EQUALLY	CHI-SQUARE	SIGNIFICANT DIFFERENCE (Y/N) CRITICAL VALUE = 5.9	FAVOURED
Q. 127 ***In most TV programmes, I expect that the role of looking after sick children is played by...***	ALL Girls	248	10	93	1.4	N	
	ALL Boys	163	11	65			
Q. 129 ***In popular magazines I expect that the people who look after the sick are mostly portrayed by a...***	ALL Boys	189	13	146	4.5		
	ALL Boys	119	18	103			

There was also no significant difference in the percentages of girl and boy learners who selected the category 'women' in response to the statement of who they expect would look after sick people as portrayed in films or on television. In response to these statements, girls and boys clearly favoured women to look after sick people rather than men in their expectations. The above comment is borne out in Figure 5.29 below by the percentage responses of the learners:

FIGURE 5.29

Statement 127: In most TV programmes, I expect that the role of looking after sick children is played by...

Statement 129: In popular magazines I expect that the people who look after the sick are mostly portrayed by...

	LEARNER'S GENDER	% LEARNERS WHO SELECTED WOMEN	% LEARNERS WHO SELECTED MEN
Statement 127	GIRLS	53.8	3.7
	BOYS	68.2	4.6
Statement 129	GIRLS	54.3	3.7
	BOYS	49.6	7.5

Both girls and boys have high expectations that women should look after sick people. The pattern of learner responses to these statements is in keeping with their responses to the statement "Women are better at looking after sick people than men", reflected in the table below.

FIGURE 5.30

Statement 109: Women are better at looking after sick people than men.

RESPONSE PERCENTAGES FOR CATEGORIES: AGREE	GIRLS %	BOYS %
Grade 7	60.9	70.1
Grade 8	54.3	60.8
Grade 9	43.3	48.8

In the Grade 7s' response to the statement, an average of 60.9% of the girls and 70.1% of the boys agreed that women are better at looking after sick people. The pattern of responses to this statement for all three grades is similar and shows a strong agreement, as is indicated in Figure 5.30 above. The statistics indicate that the stereotypical image of women looking after the sick is fairly rooted in girls and boys. The intensity of the responses, and thus the stereotypical perception, is strong in Grade 7 but decreases to the lowest percentile in Grade 9. This is in keeping with the apparent growth, also revealed in the in-depth interviews, in empowerment, especially of girls, away from society's stereotypical images, roles and careers of caring and nurturing, to a more equitable, shared responsibility for this type of pursuit.

5.3 Concluding remarks

The findings from the quantitative analysis presented in this chapter clearly indicate that gender and particularly gender stereotyping play a role in learners' perceptions of, interests in and attitudes and exposure to science and science careers. Learners' reported parental perceptions also show evidence of gendered perceptions regarding science and their children's interests. Further, there is a definite shift in attitudes and interest as learners progress into higher grades and this is shown to be gendered. As boys get older, they develop a stronger interest in how science applications work. There is a concomitant intensifying disinterest from girls from Grades 7 to 9. Boys are tuned into the symbolically masculine need for a sense of technical mastery. This appears to be due to the impact of socio-cultural effects. The impact of the media cannot be discounted since learners perceive the media as gendered and their expectations of what will appear in the media are clearly gender-stereotyped. The closer an activity is to what is viewed as 'hard core' applied science (like automotive engineering, which already has a masculine image in society because it has to do with cars) the more gender-stereotyped the activity is categorised to be.

There are, however, indications that the influence of gender equality policies and practices in social, public service institutions like government, as well as the rhetoric of women's empowerment, are having an effect on the perceptions and attitudes of especially girl learners, but also the more mature Grade 9 boy learners, as they express their views on the expectations of gender representivity in science and science careers. However, whilst boys and men appear to want to maintain the gender stereotype with regard to tasks and careers traditionally practised by women, girls are moving away from this stereotyping and becoming more aware, possibly owing also to the messages received from women's empowerment voices, of their equal rights in this modern society. There is nevertheless a tendency, even amongst girl learners who are more vociferous of women's rights, to stay close to the gender stereotype when the roles, tasks and careers come closer to the primordial task of women as 'givers of birth, caregivers and nurturers of infants'.

Where an activity is linked to women's physiological and reproductive role, and especially where this role involves caring and nurturing, most learners tend to gender-stereotype the activity in favour of women. Grade 9 girls, being in the throes of physiological development to full womanhood (as in able to reproduce), are showing a stronger inclination towards categorising activities that are linked to caring and nurturing commensurate with their age into the arena of mainly women's activities.

Learners' perception of science is also mediated, across gender and grade boundaries equally, by socio-economic factors like the financial status and social class of families, especially where these affect the geographical location of the home and the school that the learner attends. An aspect like

access to the Internet is an important aspect of these socio-economic factors. It is also clear that, across gender and grades equally, the shortcomings in learners' reading and communication abilities affect the level and quality of their access to science and science education. The findings indicate that parents reportedly follow the gender stereotypes in their aspirations for their children: fathers are keen for their boys to follow science careers and for their girls to follow non-science careers whereas mothers, on the other hand, are keen for both genders to pursue non-science careers. There are thus clear gender differences in the interests and activities of GET learners with regard to science.

It would appear that the popular print media, and more so electronic media, play a role in the space of gender representivity in science and science careers and are impacting on learner opinions as access to technology becomes more widespread. The gender images that are utilised by the media in advertising especially appear to have an impact on learner perceptions of stereotypes in science and science careers – learners internalise these gender and race stereotypes and certainly expect to see them in the media. As learners progress in school, mature and become more experienced, they appear to be becoming more discerning, and the effects of gender-stereotyping through the media appears to weaken. Much needs to be done in families as the core social unit where young people's attitudes and perceptions are shaped and nurtured, especially also by using popular media channels that appeal to young people, to break down stereotypical perceptions of gender roles, in pursuit of a society where there is equal treatment of and regard for women in the domain of science and science education. Formal education has a vital role to play here as well.

CHAPTER SIX
Gender and science education at school

6.1 Introduction

In focusing on the school and educational context of science learning, Chapter Six continues the analysis of the survey questionnaire data, focusing on how the larger school contexts and the dynamics in science classrooms are reportedly interceded by gender. Learners were asked to respond to questions about how they perceived themselves in science classrooms; their enjoyment and general feelings, including expressed anxiety, in science classrooms; what they thought about their own as well as the other gender's performance in science classrooms; and their perceptions and views of science teachers in their science classrooms. Learners' reported involvement in extra-curricular science activities were also analysed for any indications of a difference in responses based on their gender.

The themes of the research questions cover the impact of gender on learners' perceptions of science and science education during the GET Phase of their education and how socio-economic and cultural forces in society, mediated by gender, impact these perceptions.

Formal schooling, and interaction in science classrooms in particular, play a pivotal role in forming, nurturing, enhancing and advancing learners' science interest and activities. The actions of science teachers, their pedagogical methods and personal perceptions of science and science education, are crucial, as these intercede in the way that gender mediates the science experience of learners in formal schooling. The importance of the role of formal schooling in countering the effects of gender stereotyping in society is well put by Arnot (2000, p.300) who argues that:

> "In the twenty-first century, school systems across the world will have to address highly complex sets of gender relations which, having been released from the straight-jacket of nineteenth century values, are likely to find global forms of expression."

6.2 Learners of science in school classrooms

The statements grouped in Figure 6.1 below attempt to establish how learners perceived themselves in science classrooms, their levels of enjoyment of science in school and how these feelings manifest in their behaviour in science classrooms. Learner enjoyment of science lessons ranged from how much fun they had in science to their anxieties in their interactions in science classrooms. The statements also elicited responses from learners about their emotional experiences in science classrooms, how they express these feelings and the extent to which they act out in science classrooms. Figure 6.1 below also provides a picture of the distribution of Grades 7, 8 and 9 learners' responses. Except for responses to Questions 88 and 92, there is no significant difference in

the statistics of the responses of the girls and boys generally. This means that boys and girls are experiencing largely similar feelings towards various issues and situations in science classrooms.

FIGURE 6.1: **CHI-SQUARED TESTS:**
Grades 7, 8 and 9 learner responses to anxiety in science/
Learner perceptions of self in science classrooms
(Girls: n = 356 Boys: n = 244)

Comment [LG3]: Check

STATEMENT NUMBERS	GENDER	AGREE	DISAGREE	CHI-SQUARE	SIGNIFICANT DIFFERENCE (Y/N) CRITICAL VALUE= 7.8	FAVOURED
73. I am usually more worried about Natural Science (NS) tests than other tests.	Girls	172	182	5.3	N	
	Boys	104	139			
80. Sometimes my science teacher makes me feel stupid.	Girls	112	242	1.1	N	
	Boys	87	157			
88. I enjoy learning Natural Science (NS).	Girls	290	66	10.2	Y: 5%	Boys enjoy science slightly more.
	Boys	208	35			
89. Natural Science (NS) is fun.	Girls	277	75	5.5	N	
	Boys	193	49			
90. I have a good feeling towards Natural Science (NS).	Girls	257	98	5.6	N	
	Boys	184	58			
92. In Natural Science (NS) class I feel 'lost' because I don't understand the concepts.	Girls	101	255	8.6	Y: 5%	Boys feel slightly less 'lost' than girls.
	Boys	53	189			
93. I copy Natural Science (NS) homework from my friends more than other learning area homework because I don't understand the concepts in Natural Science (NS).	Girls	47	307	0.3	N	
	Boys	31	212			
94. In Natural Science (NS) class I walk around and am more disruptive than in other classes because it means I don't have to do the work.	Girls	30	324	0.6	N	
	Boys	21	221			
95. I talk to my friends more during Natural Science (NS) lessons than other learning area lessons because I don't like the work in Natural Science (NS) lessons.	Girls	62	294	1.9	N	
	Boys	36	207			
96. I copy more in NS tests because I don't understand the work.	Girls	26	329	0.8	N	
	Boys	14	227			
97. I don't like participating in Natural Science (NS) lessons because I don't understand the work in science.	Girls	53	301	2.9	N	
	Boys	38	205			

Learner responses to the statements alluding to attitudes towards science and categories of enjoyment of the science learning experience in the classroom indicate a very positive relationship to science education for both genders, across Grades 7, 8 and 9. The results of the chi-squared tests reveal that, except in response to Questions 88 and 92, learners in Grades 7, 8 and 9, from both genders, appear to be enjoying their science lessons. The chi-squared test result for Statement 88 indicates that boys are having a slightly more positive experience than girls in learning science. This finding correlates with the responses of girls, but especially boys in the in-depth interviews that exposed the stereotypical perception that boys are more suited to involvement in science than girls. The statistical analysis reveals that in the learners' response to Statement 92, boys feel slightly less 'lost' than girls in science classes. In summary, there is little difference between the reported experiences of girls and boys in science classrooms with regard to the enjoyment of science.

As far as enjoyment of science is concerned, the move from primary to secondary school was investigated to try to establish if there are changes and differences between the grades and the genders. This was done to respond to the research question that enquired about the extent of the gender difference, if any, in learners' science interest in Grades 7 through 9, especially as it appears that they enter Grade 6 with an equal interest in science. On further analysis of the data to ascertain if differences manifest between primary and secondary school and whether these differences are gender-related, the statistics for science enjoyment of Grades 7 and 9 girls and boys revealed significant differences between Grade 7 and Grade 9 girls' enjoyment of science, as indicated in Figure 6.2 below:

FIGURE 6.2: **CHI-SQUARED TESTS: Statements 88, 89:**
Grades 7 and 9 learner responses to enjoyment of science
(Girls Grade 7: n = 120; Girls Grade 9: n = 120; Boys Grade 7: n = 80; Boys Grade 9: n= 80))

STATEMENT NUMBERS	GENDER	GRADE	AGREE	DISAGREE	CHI-SQUARE	SIGNIFICANT DIFFERENCE (Y / N) CRITICAL VALUE = 7.8	FAVOURED
88. ***I enjoy learning Natural Science (NS).***	GIRLS	7	105	15	9.4	Y: 5%	
		9	95	25			
	BOYS	7	75	5	5.5	N	
		9	67	13			
89. ***Natural Science (NS) is fun.***	GIRLS	7	105	13	4.7	N	
		9	94	24			
	BOYS	7	72	7	8.3	Y: 5%	
		9	60	20			

Whilst an analysis of the data of responses to the statement about the enjoyment of science shows that one can, with 95% confidence assert that there is a significant difference between the responses of the girls in Grades 7 and 9, with Grade 7 girls enjoying science more than Grade 9 girls,

there is also an almost 10% difference in the number of Grade 7 girls and boys enjoying science. This difference favours the Grade 7 girls and boys, which indicates erosion of the enjoyment levels of science across genders, from Grade 7 to Grade 9. This deterioration in enjoyment is matched by a deterioration from Grade 7 to Grade 9 in learners' perceptions of themselves as 'good science learners' and their view that science is fun. There is thus a change in perceptions of and attitude to science from primary to secondary school, with secondary school learners exhibiting a drop in enthusiasm. This change in attitude was also noted in a study, previously cited in this research, by George (2006, p.587) who linked the changes to perceptions of the utility of science and found that:

> "The most important insight gained from the present study is that, over the middle school and high school years, changes in students' attitudes towards science are positively related to changes in attitudes about the utility of science."

Evaluation of one's performance evokes feelings of anxiety in most people and the learner responses to the statement that referred to being worried about science tests did not differ. A fairly even percentage of girl and boy learners, per category, responded similarly to the statement that referred to being worried about science tests. This means that boys and girls across the three grades feel equally apprehensive, or not, about evaluation in natural science.

6.3 Learners' emotional experiences in science classrooms

Bullon's (2001, p.191) definition of 'emotion' as "a strong feeling such as love or hate" and 'emotional' as "connected with people showing how they feel" would place feelings of enjoyment and anxiety into the context of the emotional experiences of learners in science classrooms, for the purposes of this thesis. Perceptions of science as a challenging subject that requires higher order cognitive skills, based on learner performance in formal examinations in the FET Phase in the subject and the enhanced admission requirements for the subject at the tertiary education level, trigger an anxiety amongst learners about whether they will be able to perform well in the subject. This anxiety, especially when facing formal evaluation in the subject, affects learners' emotional experiences in science classrooms.

Statements in the survey questionnaire went into more detail with regard to the emotional experiences of learners in science classrooms and specifically pointed towards practical ways in which learners gave vent to these feelings of being uncomfortable in science classrooms. In the statements to which the learners had to respond, focus was placed on some of the negative actions of learners in classrooms generally as they respond to specific experiences or situations that might unsettle them. These statements differ from those that elicited responses from learners about generally enjoying, or not enjoying, science as a subject. Learners across grades and gender responded to the statements

about feelings in science classrooms by disagreeing in varying degrees with negative statements about activities in science classrooms. A 'very high' correlation of .99 was returned when statistics of girls' and boys' responses to statements about emotional experiences in science classrooms were subjected to Spearman's Correlation Coefficient testing. This substantiates the view that both girls and boys across the grades are having positive experiences in science classrooms. In corroboration, Spearman's Correlation Coefficient test for the correlation between statistics of responses of boy and girl learners for statements that alluded to feelings towards and enjoyment of science returned a 'perfect correlation' of 1. This strengthens the view that, by grade, there is little or no difference between girls and boys generally with regard to enjoying science in school, and confirms the positive science classroom experience of Grades 7, 8 and 9 learners of both genders even more strongly. Statistical analysis of learner responses to statements about science enjoyment and feeling 'lost' in the science classroom, confirm, albeit to a small extent, that boys report a slightly more positive experience in science classrooms. This finding correlates with findings of the qualitative data reported in Chapter Seven, the chapter that deals with learner responses in the in-depth interviews.

There is a need to establish whether learners lose their enthusiasm for science when they move from primary to secondary school or if the particular focus of their science interest and experience changes over time. All the Grade 7 learners who participated in the survey questionnaire were located at the primary school and all the Grade 9 learners were at the secondary school. Grades 7 and 9 learners' responses to statements about their emotional experiences in science classrooms were compared to establish whether there was a significant difference in the categories selected by girls and boys in the different grades. The questions deal with feelings towards science and expressing those feelings by acting out in the classroom. This comparison was done to establish if there was an intra-grade (girls and boys in the same grade) and inter-grade (girls and boys from Grades 7 and 9) difference between boys and girls when learners moved from the primary school Grade 7 to the secondary school Grade 9. Figure 6.3 below presents the data about these specific questions:

FIGURE 6.3: **CHI-SQUARED TESTS:**
Grade 7, 8 and 9 learner responses to anxiety in science // Learner perceptions of self in science classroom
(Girls Grade 7: n = 119 ; Boys Grade 7: n = 80 ; Girls Grade 9: n = 120; Boys Grade 9: n = 80)

Comment [LG4]: check

STATEMENT NUMBERS	GENDER	GRADE	AGREE	DISAGREE	CHI-SQUARE	SIGNIFICANT DIFFERENCE (Y / N) CRITICAL VALUE= 7.8	FAVOURED
73. I am usually more worried about Natural Science (NS) tests than other tests.	GIRLS	7	54	65	9.3	Y: 5%	Grade 9 girls more 'worried'.
		9	75	45			
	BOYS	7	32	48	7.7	N	
		9	42	38			
90. I have a good feeling towards Natural Science (NS).	GIRLS	7	95	24	2.7	N	
		9	86	34			
	BOYS	7	64	15	8.9	Y: 5%	Grade 7 boys feel slightly better.
		9	58	22			
92. In Natural Science (NS) class I feel 'lost' because I don't understand the concepts.	GIRLS	7	35	85	8.7	Y: 5%	Grade 7 girls feel very slightly more 'lost'.
		9	36	84			
	BOYS	7	13	66	4.2	N	
		9	23	57			
93. I copy Natural Science (NS) homework from my friends more than other learning area homework because I don't understand the concepts in NS/ Natural Science.	GIRLS	7	8	112	5.9	N	
		9	20	100			
	BOYS	7	6	74	9.0	Y: 5%	
		9	14	66			
95. I talk to my friends more during Natural Science (NS) lessons than other learning area lessons because I don't like the work in Natural Science (NS) lessons.	GIRLS	7	12	108	2.5	N	
		9	12	108			
	BOYS	7	9	71	5.0	N	
		9	14	66			
97. I don't like participating in Natural Science (NS) lessons because don't understand the work in science.	GIRLS	7	13	106	4.5	N	
		9	20	99			
	BOYS	7	13	67	0.06	N	
		9	14	66			

Despite the largely similar responses of girl and boy learners across Grades 7 to 9, to questions relating to their perceptions of self and their anxiety levels in science classrooms, there are differences between Grades 7 and 9 and between girls' and boys' responses when specific questions relating to their emotional experiences in science classrooms are put to them. A statistical analysis of the responses to the statement relating to feeling worried about science tests indicated that there is a significant difference between Grade 7 and Grade 9 girls' anxiety levels during assessment in science. The null hypothesis, that there is no difference, can be rejected at the 5% level of significance; it can therefore be asserted with a 95% level of confidence that there is a significant difference between their responses. The difference appears to favour the Grade 7 girls, with the

Grade 9 girls being more 'worried' about science tests. When compared to the Grades 7 and 9 boys, the Grades 7 and 9 girls appear to be slightly more worried than the boys. Statistics also indicate that there is a significant difference between Grades 7 and 9 boys with regard to the statement concerning feelings towards science. This difference favours the Grade 7 boys, who appear to feel more positive. There is also a statistically significant difference between Grades 7 and 9 girls' responses to the statement that enquired about feeling 'lost' in the science classroom. Grade 7 girls appear to feel slightly less 'lost' than Grade 9 girls. In keeping with the Grade 9 girls, more boys in Grade 9 also appear to feel 'lost' in the science classroom than Grade 7 boys. There is a statistically significant difference at the 5% level between the Grade 7 and Grade 9 boys' responses to the statement that, whilst related to understanding science concepts, was also about copying science homework. 20% more Grade 7 than Grade 9 boys selected category 4 ("Disagree a lot") and therefore disagreed that they copied science homework because they did not understand the concepts. A larger percentage of Grade 9 boys selected categories 1 through 3 than did the Grade 7 boys for this particular statement. There appears to be no statistically significant difference between the responses of girls and boys and Grades 9 and 7 to the statements that related to reactions to curriculum work in science classrooms. Responses to these questions fit the pattern of largely positive feelings towards science in the classroom. The research question relating to the possible loss of interest in science as learners move from Grade 7 to Grade 9 is thus confirmed, more so for girls than boys.

It is apparent that, in varying degrees, learner anxiety levels in science classrooms is increasing from Grade 7 to Grade 9 for both boys and girls, but that there is no significant gender difference regarding these degrees of 'angst'. Girls are getting more worried about science tests as they move from Grade 7 to Grade 9 and slightly more Grade 9 girls are experiencing a feeling of being 'lost' in science classes. This growing anxiety is 'supported' by a small drop in confidence levels regarding science in the girls, with the drop being more pronounced for the boys from Grade 7 to Grade 9. This trend, interpreted as increasing anxiety and a decreasing confidence in their ability in science, could be the reason why fewer female learners are selecting Physical Sciences in the FET course, and the subsequent fewer numbers of girls entering science faculties at tertiary institutions.

6.4 Gendered attitudes and perceptions of performance in science classrooms

The debate about whether gender has a role to play in explaining differences in the performance levels of girls and boys in science rages on. As explanations are sought, boys and girls in science classrooms are cultivating attitudes to perceived differences in performance in science classrooms. Statistics of learner responses to perceived performance in science were analysed for

possible differences between girls and boys. Learners' perceptions of which gender performed better and particularly the boys' perception of girls' performing well in science were investigated in order to establish whether boys regard science as a masculine domain in which girls could not perform better because they were girls. Statement 74 establishes learners' opinions of which gender performs better in science in Grades 7 to 9, whereas Statements 112, 113 and 114 establish the attitudes towards girls who perform well in science. The data in Statement 74 indicate that 70.6% of the girls agree with the statement compared to the 29.4% who disagree, indicating that most of the girls are clearly of the opinion that they perform better than boys in Natural Science examinations. This is in contrast to the boys where there is an almost even split between those who agree (50.6%) and those who disagree (49.4%). Girls are thus more confident of their better performance in Natural Science examinations. An investigation of the data regarding the attitude to girls who perform well in science, whether it be their ability to 'get boyfriends', their likeability or their being 'cool', indicates a clear disagreement from both boys and girls that performance in science examinations elicits negative emotional responses. The data from boys and girls for the statement that referred to the romantic attractiveness to boys of girls who perform well in sciences are a little less strong in agreement. The percentage of boys who agree with the statement about girls who perform well in science getting a boyfriend nears the 40% mark: this could be an indication of boys' apprehension about relationships with more intelligent girls who could possibly threaten the power and hegemonic aspects of their masculinity. Figure 6.4 below sets out the statistics of the responses:

FIGURE 6.4 **CHI-SQUARED TESTS:**
Grades 7, 8 and 9 learner responses to perceptions of girls' performance in science
(Girls *n* = 356 Boys *n* = 244)

STATEMENT NUMBERS	GENDER	AGREE	%	DISAGREE	%	CHI-SQUARE	SIGNIFICANT DIFFERENCE (Y / N) CRITICAL VALUE = 7.8	FAVOURED
74. ***The girls in our class usually do better than the boys in Natural Science (NS).***	ALL Girls	250	70.6	104	29.4	33.4	Y: 1%	Girls agree more with statement.
	ALL Boys	123	50.6	120	49.4			
112. ***Girls who are very good in science at school don't get boyfriends as quickly as girls who really don't like science.***	ALL Girls	100	28.1	256	71.9	20.9	Y: 1%	Girls disagree more with statement.
	ALL Boys	91	37.9	149	62.1			
113. ***I don't like girls who always get very high marks in science.***	ALL Girls	38	10.7	316	89.3	20.5	Y: 1%	Girls disagree more with statement.
	ALL Boys	43	17.9	197	82.1			
114. ***My friends and I think girls who are very good in science are NOT cool.***	ALL Girls	40	11.3	313	88.7	16.5	Y: 1%	Girls disagree more with statement.
	ALL Boys	34	14.4	202	85.6			

In a statistical analysis of learner responses to statements about learner performance in science, the chi-squared values are all greater than the critical value (11.3) at the 1% level, which means that the null hypothesis that there is no statistically significant difference between the responses between girls and boys in Grades 7, 8 and 9 can be rejected at the 1% level. It can thus be stated with 99% confidence that there is a statistically significant difference between the responses of girls and boys across Grades 7 through 9. This means that, in responses to Statement 74, girls and boys disagree with the statement that girls usually do better than boys in science. A high percentage of both girls and boys strongly disagree with the statements about the likeability of girls who perform well in science, which means that these girls are not disliked and are not perceived as socially unacceptable. Implicit in this statement by both girls and boys is the acceptance of the positive image of science and that there are no negative spin-offs for girls as a result of their involvement in science. There are, however, differences in the strengths of the opinions expressed. Girls disagree more with the boys' responses to the statements and the boys agree more with the statements. This agreement is more pronounced in Grade 7 than in Grades 8 and 9 and recedes from Grades 7 to 9. The above comment gives some indication that boys are affirming the stereotype of science as a male pursuit whereas girls appear to be moving away from the stereotype. This phenomenon is also evident in the qualitative analysis of the in-depth interviews, as well as in

statistics elsewhere in this research. It supports the general assertion that boys are defending and maintaining the stereotype whereas girls are challenging and moving away from it.

6.5 Learners' perceptions of the value of science education

Society is currently experiencing what is popularly known as the technological age, which is underpinned by advances in science. Applied science, in the form of technological appliances that make our modern world easier to negotiate, forms an important part of our everyday lives. The survey questionnaire established what learners think about science and the importance and uses of science education. Whilst it is acknowledged that young people especially are attracted to technology that makes it easier for them to negotiate their social experiences, the pursuit of science in academia is generally regarded as challenging for them and enhances the regard they have for the value of science and science education for their lives as well as for society.

Statements that related to the value and importance of science and science education were grouped and put to the learners. The statistics are indicated in Figure 6.5 below:

FIGURE 6.5: **CHI-SQUARED TESTS:**
GET Learner responses to perceptions of scientists and the importance of science education
(Girls *n* = 356 Boys *n* = 244)

STATEMENT NUMBERS	GENDER	AGREE	DISAGREE	CHI-SQUARE	SIGNIFICANT DIFFERENCE (Y / N) CRITICAL VALUE = 7.8	FAVOURED
77. ***I think learning science will help me in my daily life.***	ALL Girls	275 (77.7%)	79	3.3	N	
	ALL Boys	198 (81.5%)	45			
87. ***We learn about important things in the Natural Science (NS) class.***	ALL Girls	325 (91.5%)	30	4.5	N	
	ALL Boys	228 (93.8%)	15			
102. ***I think scientists are 'cool' people.***	ALL Girls	266 (75.4%)	87	2.1	N	
	ALL Boys	174 (72.8%)	65			
103. ***Everyone should learn about science.***	ALL Girls	278 (78.5%)	76	0.7	N	
	ALL Boys	185 (77.4%)	54			
115. ***Science is good because scientists invent cool gadgets that I can use.***	ALL Girls	301 (85.0%)	53	6.7	N	
	ALL Boys	217 (90.8%)	22			
116. ***Science improves the lives of people because scientific inventions have helped farmers to produce more food and therefore fewer people go hungry.***	ALL Girls	297 (83.9%)	57	3.9	N	
	ALL Boys	206 (85.8%)	34			

72.8% to 93.8% of the learners agree with the statements. This showed that a large percentage of learners across grades and genders are positive about scientists and the importance of teaching science. There is a slightly stronger but statistically insignificant difference between the responses of the boys as compared to the girls to statements about the benevolence of science. Boys' responses, regarding the value of science in daily life are slightly stronger than those of the girls, indicating a slightly bigger appreciation of the value of science and its applications. Slightly more boys also agreed on the value of what they are learning in science. The closeness, similarity and size of the percentages of the responses point towards a general positive agreement of boy and girl learners on the value of science and science education.

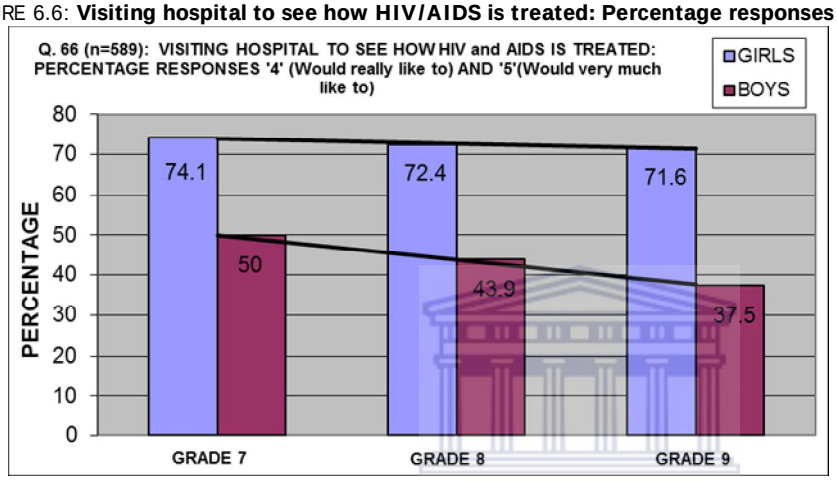
The statistics indicate that learners' positive perception of science, as previously demonstrated in their responses in the survey questionnaire, is not limited to the classroom experience but also encompasses its role of facilitating society's functioning via science applications.

6.6 Learners' involvement in extra-curricular science-related activities

Learners' active pursuit of science activities outside of the home and school is an indication of a more serious interest in science. Learners were surveyed about more formal science-related activities, outside of the home environment, that they would want to pursue in future. Statements 64 to 67 contained activities that would indicate the extent to which learners engaged in activities that could be construed as exhibiting an interest in science. These activities were learning activities that could form part of a school science curriculum but are usually additional to it. Statement 64 asked for semantically graded responses about involvement in a science competition. Across Grades 7 through 9, girl and boy learners responded in a range of 52.5% to 68% in categories one ("would like it very little") and two ("wouldn't really like to"). This indicated a low enthusiasm for involvement, perhaps because it involved the testing of knowledge, to which learners might have a 'natural' aversion. When the response required involved participating in what science had to offer, as in Question 65 (go on a visit to the aquarium), there was a marked increase in the number of learners across the grades and gender who responded in categories four ("would really like to") and five ("would very much like to"). 60.1% of the learners responded to these categories and there was no significant difference between the responses of the girls and boys. There was an even more marked response from the girls (an average of 72.7%, across grades, when they were asked in Question 66 to respond to the possibility of visiting a hospital to see how HIV and AIDS patients are treated. In keeping with the tendency, in this research, for girls to be more enthusiastic about affective science, where caring and nurturing play a role, the average response from the boys in categories four and five, across grades, was 43.8%. This constitutes a difference to the average of the girls' responses, of 28.9% as is indicated

in the graph below. Clearly boys have been socialised to not see caring for the sick as part of the realm of the actions and information they, as boys, require in their gender role; they do not regard it as a symbol of their masculinity. They do not see the experience as fitting their expectations or interests as boys, and increasingly so, as they progress through the grades and grow older. This indicates a solidifying of boys' attitudes, in respect to this aspect, as they grow into men.

FIGURE 6.6: **Visiting hospital to see how HIV/AIDS is treated: Percentage responses**



This could be interpreted as, where the science activity involves caring and nurturing, girls are more enthusiastic to get involved than boys, across Grades 7 through 9 and that boys' gendered perception is that this activity rests in the girls' domain. The trend line in the above graphic representation also indicates a more marked decline in the percentage responses of the boys from Grade 7 to Grade 9 whereas the girls' response percentage is more or less stable at 72% to 74%. This means that, as the boys get older and mature, their gendered perceptions of the activity as one for girls increases, which indicates a strengthening of the gender stereotype.

When asked to respond to the statement regarding "belonging to a science club", the responses from both genders and Grades 7 through 9, ranged from 33.2% to 50% in categories one and two, indicating a low enthusiasm for participation. It would appear, from the responses to the statements about participation in science activities in future, that there is more enthusiasm across grades and gender, for participating in what science has to offer in its application, than actually 'doing' science or engaging in science activity. This trend reflects an aspect of modern, 21st century society that has popularly become known as 'the consumer society', where goods and services are being 'consumed' by the population in order to serve individualistic needs.

6.7 Learners' perceptions of their own performance in science classrooms

To establish if there are gender differences in how learners perceive their own performance in science, statements in the survey questionnaire relating to this were grouped and the data analysed. Figure 6.8 below presents the data of learner responses to these statements that relate to learners' personal perceptions of how they are performing academically in science, and their evaluation of themselves as science learners:

FIGURE 6.7: **CHI-SQUARED TESTS: Statements 70, 72, 78**
GET learner responses to performance in science
(Girls *n* = 354 Boys *n* = 246)

STATEMENT NUMBER	GENDER	AGREE	DISAGREE	CHI-SQUARE	SIGNIFICANT DIFFERENCE (Y / N) CRITICAL VALUE = 7.8)	FAVOURED
70. *I usually do well in Natural Science (NS).*	ALL Girls	293	61	0. 31	N	
	ALL Boys	198	46			
72. *I consider myself a good NS/ Natural Science learner.*	ALL Girls	257	97	2.2	N	
	ALL Boys	175	68			
78. *NS/ Natural Science is not one of my strong subjects.*	ALL Girls	187	167	13.4	Y: 1%	
	ALL Boys	133	109			
104. *I will probably not do well in N/S Natural Science in the examinations.*	ALL Girls	202	153	7. 6	N	
	ALL Boys	140	100			

The responses of girls and boys to these statements indicate that an average of 81.5% across Grades 7 to 9 feel that they usually do well in natural science but that a lower average percentage of 71.9% consider themselves to be good science learners, indicating perhaps, a perception of the overall challenging nature of the pursuit of science. This high regard for the status of science and its pursuit in academia, as that for which only 'intelligent' people are suited, is also evident in the learners' responses to the in-depth interviews.

There is a statistically significant difference between the categories of responses selected by girls and boys to the statement that investigated their perceptions of their performance in science as compared to their other subjects. Slightly more boys and girls selected responses that indicated that they agree with the statement that science is not one of their strong subjects. That would indicate that learners across Grades 7 through 9 appear to be experiencing challenges with the subject as compared to their other subjects. Boy and girl learners' response to the statement that alluded to future performance in Natural Science was very similar and underscores the responses to the statement that science was not regarded by learners as their strong subject. It appears that GET

science learners do not feel confident about sustained good performance in science, exposing a feeling of uncertainty, perhaps in response to the perception that it is a challenging subject.

It needs to be pointed out that a separation of the content of science into the theoretical and practical aspects was not done when learners were asked to respond to the statement that science is not regarded as the learner's strong subject. Learners' perceptions of their performance were thus based on all aspects of the subject as a whole.

Possible changes in learners' perceptions of their performance in Natural Science as they moved from Grade 7 to Grade 9 were investigated by analysing the data of Grade 7 as compared to Grade 9 responses. These two grades represent a change in schooling phase from primary to secondary school, and in emotional and social maturity levels, as learners experience the onset of adolescence. The results, indicated in Figure 6.9 below, show that, with the exception of the responses of Grades 7 and 9 girl learners to the statement, they considered themselves good science learners. There appears to be no statistically significant gender difference between Grades 7 and 9 boy and girl learners in the categories of responses that they selected, which means that both girls and boys have similar perceptions of their performance.

FIGURE 6.8: **CHI-SQUARED TESTS: Statements 70, 72, 78 and 104**
Grades 7 and 9 learner responses to performance in science
(Girls Grade 7: n = 119; Boys Grade 7: n = 80 ; Girls Grade 9: n = 120; Boys Grade 9: n = 80)

STATEMENT NUMBER	GENDER	GRADE	AGREE	DISAGREE	CHI-SQUARE	SIGNIFICANT DIFFERENCE (Y / N) CRITICAL VALUE = 7.8)	FAVOURED
70. I usually do well in NS/ Natural Science.	GIRLS	7	106	11	3.1	N	
		9	100	14			
	BOYS	7	69	9	4.9	N	
		9	63	12			
72. I consider myself a good Natural Science (NS) learner.	GIRLS	7	95	22	7.9	Y: 5%	More Grade 7 girls agree.
		9	87	22			
	BOYS	7	65	14	7.4	N	
		9	54	22			
78. NS/ Natural Science is not one of my strong subjects.	GIRLS	7	63	31	1.9	N	
		9	61	29			
	BOYS	7	35	27	3.5	N	
		9	45	24			
104. I will probably not do well in science in the examinations.	GIRLS	7	45	39	3.2	N	
		9	43	31			
	BOYS	7	27	27	4.2	N	
		9	21	38			

The statistically significant difference between the categories of responses selected by the Grades 7 and 9 girls in the statement that they considered themselves good science learners is at the 5% level. This indicates that the researcher can, with 95% confidence, state that Grade 7 and Grade 9 girls differ in the strength of their perceptions of themselves as science learners. This difference favours the Grade 7 girls since there are statistically more of them who consider themselves good science learners. Whilst the data for the boys do not indicate a statistically significant difference, more Grade 7 boys also consider themselves good science learners than Grade 9 boys. Grades 7 and 9 boys appear to be slightly more confident than Grades 7 and 9 girls that they will do well in the science examinations. Most of the Grades 7 and 9 learners agreed to the statements that they are doing well in science and consider themselves good science learners. There is, however, a general decrease in the percentage of boy and girl learners from Grade 7 to Grade 9 who regard themselves as usually doing well in Natural Science and who consider themselves good science learners. This means that as the learners progress from Grade 7 to Grade 9 their confidence levels are dropping, with the boys experiencing the bigger drop.

In contrast to the statements about performance in science (Statement 70) and regarding oneself as a good science learner (Statement 72), the word 'not' was introduced in Statements 78 and 104 to present a negative statement in order to test the validity of learner responses. In other words, Statements 70 and 104 as well as Statements 72 and 78 are similar, except for the word 'not' having been inserted in Statements 104 and 78 respectively. This insertion was done in an attempt to test the validity of the learners' responses. More learners, across grade and gender, were in agreement with the statements about usually doing well in science (Statement 70) and regarding themselves as good science learners (Statement 72); however, they also agreed with the statement about science not being their strong subject. This shows that the response patterns do not corroborate each other, perhaps because the learners see a difference between being a good science learner and science being a strong subject for them.

It appears that learners across the grades are finding the subject more challenging as they progress through the grades and that their perceptions of achieving limited future success in the subject becomes stronger. This trend could provide one of the reasons for the decrease in the numbers of learners selecting Physical Sciences in the FET Phase, as the perception of the academically challenging nature of science takes hold. The pattern of low and fewer than desired numbers of learners selecting science for tertiary study appears to be a continuance of the trend occurring at the end of the GET Phase, as learners enter the FET Phase of education. The GET Phase would appear to be the start of the diminishing numbers in the 'science study pipeline', resulting in

low numbers of girls selecting science as a field of study and eventually entering the science careers field.

6.8 Learners' opinions of science teachers

Teachers play a significant role in science classrooms and their influence on learners, through their views and actions, are important in the perceptions of science and the gender debate. As they practice their craft, teachers bring into classrooms their own views on gender and science. This affects the way in which learners interpret this issue and their perceptions of science and science education. Learners are thus influenced by the way that teachers act in science classrooms. Specific statements relating to the actions of teachers and their performance in science classrooms were grouped and learner responses to them investigated, to establish what influence teachers have on learner perceptions of gender and science. The responses are presented in Figure 6.6 below:

FIGURE 6.9 **CHI-SQUARED TESTS:**
GET learner responses to perceptions of science teachers' pedagogy
(Girls *n* = 356 Boys *n* = 244)

STATEMENT NUMBERS	GENDER	AGREE	DISAGREE	%	CHI-SQUARE	SIGNIFICANT DIFFERENCE (Y / N) CRITICAL VALUE = 7.8	FAVOURED
81. ***Women Natural Science (NS) teachers are better than men NS teachers.***	ALL Girls	151	202	57.2	1.5	N	
	ALL Boys	110	133	54.7			
82. ***<u>My</u> best Natural Science (NS) teacher so far was a male.***	ALL Girls	164	188	53.4	2.1	N	
	ALL Boys	118	121	50.6			
83 ***Our teacher usually <u>first</u> asks a boy a question during NS/ Natural Science lessons before asking a girl.***	ALL Girls	80	273	77.3	33.1	Y: 1%	
	ALL Boys	105	138	56.8			
84. ***Our teacher usually <u>first</u> asks a boy to do experiments in the Natural Science (NS) lesson before asking a girl.***	ALL Girls	89	263	74.7	32.1	Y: 1%	
	ALL Boys	109	133	54.9			

Statements in the survey questionnaire elicit learners' views on the gender of the person whom they considered their best science teacher and on science teachers' pedagogy, specifically their gender preferences in science classrooms, in order to establish whether there is a gendered difference in learners' perceptions of science teachers' actions. A shortcoming in Statements 83 and 84 is that the gender of the teacher asking the question was not stated, which somewhat limits the analysis of the response data for gender-related differences. Results of statistical testing indicate that there is no significant difference between girls' and boys' views of the gender of 'better performing'

science teachers. Both girls and boys disagree slightly more with the statement, with the girls displaying stronger disagreement in their responses. The statements were put to the learners in this way in order to cross-check and corroborate their responses. This means that the majority of girls and boys do not think that women science teachers are better than men science teachers. The data for both statements that alluded to the gender of the science teacher that learners thought was better show a slightly stronger disagreement from the girls than the boys. Since the statements presented both genders for learners to choose as their 'better' science teacher, their responses, which are in the region of 50%, are quite evenly balanced and perhaps reflect personal preference.

The data from the statements that relate to teachers' gendered actions in science classrooms indicate that there is a significant difference between the responses of girls and boys. Whilst the genders of the science teachers were not established in the questions, the girls disagree more than the boys by a margin of about 20% in both questions. Conversely, the boys agree with the statements more than the girls, also by a 20% margin. This means that there is a strong indication that girls don't think that boys are being preferred to girls when teachers elicit responses from learners, neither do they think boys are given preference when learners are called upon to do experiments. Girls do not think that there is a gender bias in science classrooms when it comes to teachers' asking questions or requesting learners to do practical work. Whilst there was stronger disagreement than agreement to the statements amongst all the learners, the disagreement-agreement gap was wider for girls than for boys. More girls than boys felt that science teachers do not give boys preference over girls. The response data for Statements 83 and 84 also indicate that more boys agree with the statement, which indicates a perception that teachers give first choice to boys for a response to questions in science classrooms. The percentage agreement-disagreement gap of the boys' responses to Statements 83 and 84 is not as wide as for the girls, which might indicate a small degree of 'comfort' with the statement. The response data for these statements also indicate that girls do not feel discriminated against in science classrooms and there are differing perceptions and interpretations of what is happening in science classrooms.

The data for the statement that investigated the gender of the learner whom the science teachers first asks to perform an experiment were disaggregated to establish if there were response differences between Grades 7, 8 and 9 learners, and between boys and girls. A closer examination of the learner response data to this statement, as presented in Figure 6.7 below, reveals a significant difference in girls' and boys' responses at the 1% level; one can state with 99% confidence that there is a significant statistical difference between the responses of the girls and boys across the grades. This means that boys and girls differ significantly in their thinking on the actions of their teacher, as to which gender is preferred when doing practical experiments in science classrooms.

Boys are reporting that boys are favoured and girls are reporting that boys are not. Whilst this statistical difference between girls' and boys' responses also exists when the statistics for the statement about whom the science teacher first asks a question are analysed, for the statement on the practical work, the strength of the difference is greater and existed in all three grades, whereas for the statement about the questioning it exists, at the 1% level, only in Grades 8 and 9.

A closer analysis of the statistics of the Grades 7 to 9 girls' responses to the statement that 'teachers usually first ask a boy to do experiments' reveals an increase in the girls' disagreement, from Grade 7 (34%) to Grade 8 (47.8%) and Grade 9 (58%). This means that girls are becoming surer in their responses that teachers are not first asking boys to do experiments in science classrooms. Girls appear to feel that they are not being discriminated against in science classrooms because of their gender. This could also mean that, as the girls mature in science classrooms, they are experiencing a confidence in their stature and are becoming more secure in their ability to participate in science lessons. Whilst the disagreement also exists for the boys and increases in Grades 8 and 9, it is not as strong as for the girls.

FIGURE 6.10: **CHI-SQUARED TESTS:**
Grades 7, 8 and 9 learner responses to perceptions of science teachers' pedagogy
(Girls *n* = 356 Boys *n* = 244)

STATEMENT NUMBER	GRADE	GENDER	AGREE	DISAGREE	CHI-SQUARE	SIGNIFICANT DIFFERENCE (Y / N) CRITICAL VALUE = 7.8
84. Our teacher usually <u>first</u> asks a boy to do experiments in the Natural Science (NS) lesson before asking a girl.	GRADE 7	Girls	34	84	14.5	Y: 1%
		Boys	43	36		
	GRADE 8	Girls	30	85	12.5	Y: 1%
		Boys	37	46		
	GRADE 9	Girls	25	94	16.2	Y: 1%
		Boys	29	51		

Slightly more Grade 7 boys, located at the primary school, agreed to the statement that science teachers first ask boys to do experiments. Grades 8 and 9 boys, located at the secondary school, increasingly disagreed, like the girls, with the statement. Since Grade 7 is located in the primary school, there might be a need to make teachers in primary school science classrooms more aware of learner perceptions and more focused on their actions during science lessons. Primary school learners' responses in this regard are interesting, since it is generally believed that there are many more women than men teachers in primary schools and thus it is more than likely that the science teacher is a woman.

6.9 Concluding remarks

Learners' perceptions of and interest in science at the school level are varied and there are gender differences in their responses to the statements presented to them concerning this in the survey questionnaire. A closer examination of these gender differences exposed a stronger reaction to gender stereotyping on the part of girls than boys. Bendix (2000, p.435) captures this reaction when, speaking from a women's labour rights perspective, she comments that:

> "Women, too, have become more vociferous in their demands and are particularly sensitive to discriminatory practices. Thus, as the composition of the workforce shifts to include more female employees, it could happen that employees become more militant and that the establishment of women's rights and the solution of problems such as sexual harassment gain prominence as issues in negotiations."

Bendix's views thus partially summarise the findings, in this chapter, of GET learners' perceptions of science and science education.

The data from the learner responses indicate that girls and boys are generally reporting similar emotional experiences in science classrooms. On the whole they are enjoying science to the same degree and their attitudes to science are positive. This enjoyment is not limited to science classrooms but includes the value of science as facilitating their being able to deal with the modern world. There are, however, indications of small differences based on gender, and between grades. Boys are feeling a little less 'lost' in science classrooms than girls and there appears to be a significant difference between Grade 7 and Grade 9 girls' enjoyment of science. As reported in Figure 6.2 and its discussion, this difference favours the Grade 7 girls, which indicates attrition of the enjoyment levels of science from Grade 7 to Grade 9. This deterioration in enjoyment is matched by a deterioration in learners' perceptions of themselves as good science learners and their view that science is fun, from Grade 7 to Grade 9. There is thus a change in perception of and attitude to science from primary to secondary school, with the secondary school learners exhibiting a drop in enthusiasm.

Girls do not feel that they are being discriminated against in science classrooms because of their gender, whether in being required to respond by teachers or in teachers' selection of who should do practical work, although they do seem to feel that teachers give boys opportunities. However, where the science activity involves caring and nurturing, girls are more enthusiastic to get involved than boys and the boys' reported opinion is that this activity rests in the girls' domain.

The findings of the analysis of the data indicate that, as they proceed from the primary to the secondary school (see Figure 6.2 and the analysis), GET learners losing interest in science from Grade 7 to Grade 8, but this appears to even out as they reach Grade 9. As learners progress from Grade 7 to Grade 9, are exposed to modern life, pick up experience and mature in age and outlook

on life, the pursuit of science changes to one of indulgence in its usefulness in negotiating the modern world and its challenges.

The academic pursuit of science wanes as GET learners progress through to the FET Phase and as the learning area becomes concomitantly more academically challenging, resulting in fewer and fewer opting to offer the subject in the FET Phase, and fewer still taking up a career in the field of science. The throughput in the science 'pipeline' diminishes from the start of the FET Phase. In schools and in science classrooms in particular, learners are grappling with their perceptions of science. They should be comprehensively and effectively taught to regard the pursuit of academic science as a part of modern life that should be engaged in and not increasingly treated with apprehension.

The learners' responses to statements and questions presented to them in the survey questionnaires relating to their perceptions of and interest in science were complemented by those in the in-depth interviews. This is discussed in Chapter Seven that follows.

CHAPTER SEVEN
Science and gender: listening to learners' voices

7.1 Introduction

This chapter presents a thematic analysis of the findings of the qualitative study, which is an attempt to provide a richer description of the way in which science and science education are gendered through the subjective voices of a group of learners.

When learners are required to respond to a survey questionnaire, nuances in their use of language which portray particular perceptions, and even voice intonations which portray attitudes, are not evident since learners are expected to react to and select from the 'ready-made' replies that are provided. Transcriptions of the substance of interviews provide the opportunity for such fine distinctions to be picked up and comments made. Schurink (2001, p.297) comments that:

> "...the face-to-face interview helps us to understand the closed worlds of individuals, families, organizations, institutions and communities."

These nuanced responses and voice intonations of the learners allow interviewers to access the assimilated "values, norms, traditions and language" (Schurink, 2001, p.298) of the culture or society from which the learners hail. Schurink (2001, p.298) also regards the interview as "a meaning-making process" that allows access to the "closed worlds" and the contexts of the culture and sub-culture of interviewees. The analysis in this chapter of the substance of the in-depth interviews is an attempt to access and make sense of the Grades 7, 8 and 9 General Education and Training (GET) learners' 'closed worlds' regarding their perceptions of the role that gender plays in science and science education.

The analysis of the learners' discourse on gender exposes certain thematic issues that form the foundations of the learners' debates and their understanding of what makes up masculine and feminine identities. These debates take the form of comparisons of the characteristics that would make up the suitability of specific genders for activities or careers. In assigning attributes, boys and girls are constructing the characteristics of their gendered 'others'; in so doing, they put forward their interpretation of what they think should be distinctive of that other gender. The learners' expressions of their stereotypical views on the roles that they expect males and females to play, and the types of behaviour they expect of each gender in certain situations, draw on categories of attributes on which to base and substantiate their pronouncements. Frosh et al. (2002, p.97) describe these expressions as "the ways in which ...boys ...positioned themselves ...in relation to 'hegemonic' masculinities" with regard to the construction of their and the other gender's role. In this respect, learners also base their comparisons on perceived biological/physical, intellectual and emotional/psychological qualities.

The chapter also looks at the way in which learners express themselves on issues in science in order to establish how they understand the role that gender plays in science; to what extent their views about science and science careers are gendered; and particularly the way in which formal school education, society and the popular media shape their perceptions and meanings with regard to science. I will also specifically try to establish the impact of learners' own gender on their perceptions of gender in general, and gender in science in particular.

As outlined in Chapter Four, the qualitative study was preceded by a quantitative study: it was conducted to enhance the findings of the quantitative study and to deepen the understanding of the social context of the learners' lives as they express their views on science and gender. The qualitative study sought to further explore the learners' perceptions of science, science careers and science education. To this end, the statements contained in the in-depth interviews focused on topics similar to those covered in the survey questionnaire. The conversations entered into with learners focused on the way in which they perceived gender in their everyday lives, their views on careers and their science classroom experiences.

Learners' opinions were drawn out about the role that they think gender plays in socialisation, in the workplace and in their education. Their views were sought on applied science careers, such as those of medical doctors and automotive mechanics, and non-science careers like dress designing, in order to establish the extent to which gender played a role in their views on who did or should do these jobs. Elsewhere I have argued that the home is the primary site for early socialisation and that learners' relationship with people in the home are important for the formulating of gender perceptions. Activities in the home were explored and learners' comments sought in order to establish how gender influenced interaction in the home around specific activities and situations. Learners were also presented with descriptions of media images in which gender played a part and their views were sought on these.

The chapter is organised around the following key foci: the learners' gendered notions of identity and the physical and intellectual foundations of these notions and how they influence learners' views on careers; the gendered notions that learners have of careers, particularly science-related careers; the dynamics in schools and science classrooms that perpetuate the gendering of science; and the emerging resistance, amongst girls especially, to gendered notions of science.

7.2 Gendered notions of identity

Learners have gendered notions of identity. A key theme emerging from their responses in the semi-structured, in-depth interviews relates to the way in which their perceptions of identity are powerfully gendered and how this is articulated through their gender-differentiated notions of physical and intellectual prowess and the roles that people play. This discourse of difference is then used by learners, especially boys, as a way of legitimising the differences in science interest and performance that are discussed by participants.

7.2.1 Physical

The in-depth interviews show that one of the ways in which girls and boys articulate their stereotypical views on gender roles is by referring to physiological attributes and locating them in a biological framework by, for instance, comparing the purported differences in physical strength of boys and girls. Their comparisons have thus to do with the body: in other words, physical attributes and the levels of physicality that boys and girls think that women would be willing to participate in (or not). Boys and girls construct their masculine and feminine identities through social interaction and through cultural transference of ways of behaving. These socio-cultural structures are symbols of masculinity which pervade their interactions in science classrooms, peer groups, families; these structures 'police' and regulate learner behaviour to endorse the gender stereotype and ensure that they conform to it. Boys' construction of their masculinity and its expression through actions in local communities is receiving much attention: modern societies are attempting to deal with some of its negative outcomes like gangsterism, violence and substance abuse – so aptly described in *From boys to men* which contains 'ethnographic' accounts of the constructions of masculinity in socio-cultural environments in contemporary African society (Shefer et al., 2007). Connell (2007) and Frosh et al. (2002) point out that there are different kinds of masculinities that have their origin in the social structures in which boys are socialised. Frosh et al. (2002, p.75-76) further point out that:

> "there is a 'dominant' form of masculinity that influences boys' and men's understanding of how they have to act in order to be 'acceptably' male, and that this dominant mode is associated with heterosexuality, toughness, power and authority, competitiveness..."

In their research experiment on the reporting of symptoms of illness during childhood and adolescence, Maclean et al. (2010, p.599) refer to an awareness of "dominant societal expectations of boys". They comment further that, in the responses that they received:

> "The majority felt that stereotypically masculine responses in the form of displays of stoicism, independence, control and strength would be expected in response symptoms." (Maclean et al., 2010, p.599)

Connell (2007, p.ix) speaks of the development of the term 'hegemonic masculinity' as an "authoritative, in-command masculinity". This 'hegemonic masculinity' provides a backdrop to the comments by boys in the in-depth interviews and accounts for the type of words they use in expressing opinions about issues that are intersected by gender. In explaining the formation of these masculinities as the outcome of the forces and dynamics within social and cultural groups, Ratele (2008, p.516) describes this 'hegemonic masculinity' as:

> "...a mesh of social practices productive of gender-based hierarchies, including violence, that supports these hierarchies: that is, the unequal relations between females and males *as groups."*

The in-depth interviews conducted in this research show boys "positioning themselves, consciously and unconsciously, in constructing their masculine identities" (Ratele, 2008, p.525). The interviews illustrate the 'hegemonic' aspects of their comparisons with girls regarding the physical aspects of the suitability for certain tasks (emphasis mine):

KAREN (G9F13):	*...women can't ...handle ...uhm ...blood and things like that but ...men like to do ...**physical things**...*
JOEY (G7M01):	*...boys' work is outside the house. We are better with our **hands**.... Men are like ...**rough** ...**rough**." They [girls] don't want to like work with blood and things...*
LANCE (G9M09):	*...men are **stronger** ...than women ...they built more... ...'cause the women are not, not as strong as men are, OK!*
PETER (G9M11):	*...men are good with their **hands**... I won't trust a girl to do a man's job...*

References to physical attributes in comparing girls' and boys' suitability for tasks emanate mostly from boys, which shows that the stereotypical roles with which girls are identified reside strongly in boys. Boys use negative terminology to express themselves about girls' doing what they perceive to be men's work. Boys' pre-occupation with physical strength as a basis for gendering tasks comes at a time of adolescent physical and physiological change in their bodies; this influences their experiences and understanding of what it means to be 'a man' and contributes to the social construction of their masculinity. The use of words like 'rough', 'strain', 'hard', 'heavy', 'muscles' and 'strength' reflects the physical and physiological characteristics through which they define masculinity. In their research aimed at understanding boys in contemporary society, Frosh et al. (2002, pp.121-122) found that:

> "...girls and boys were commonly differentiated and homogenized in particular ways around activity and passivity, hardness and softness, humour and seriousness" (Frosh et al., 2002, p.121) and
>
> "...active, funny, physically and emotionally strong..." (Frosh et al., 2002, p.122)

> "Girls were idealized …as friendly and sympathetic and good conversationalists." (Frosh et al., 2002, p.122)

The language used by the boys in my research to describe the 'qualities' required for certain types of tasks clearly mirrors the comments made by the boys and girls in Frosh et al.'s findings. Boys were expressing themselves in terms of 'hegemonic' masculinities, and girls in terms of a different and apparently 'feminine', inferior set of qualities unsuited to the same 'masculine' tasks. In his research conducted in schools in the United Kingdom on how boys construct their masculinity, Swain (2003, p.306) comments that:

> "It was a necessary prerequisite of the informal culture for all boys to appear as being tough, and one of the boys told me that 'you can't afford to be nice 'cos people will think that you're soft inside."

In their discussion of the role of peer groups in defining masculinity for boys, MacLean et al. (2010, p.598) refer to the need for boys to show "evidence of typically 'masculine' attributes, such as hardness" and they confirm the role that physical strength plays in boys' construction of their masculinity when they state that:

> "Projection of the body as physically superior and athletic is viewed as a crucial resource for successful performances of masculinity." (MacLean et al., 2010, p.598)

It would appear from the interactions with learners in the in-depth interviews that masculinities are embedded in physicality, dominance and power relations, and especially perceived physical strength and power. In his unpublished Ph.D. thesis, Stevens (2008) speaks of "militarised modes of manhood extending well beyond the barracks and battles" (Shefer et al., 2008, p.3); he alludes to the location of physical power and strength beyond the violence of war into domains of suitability for specific tasks, careers and patterns of behaviour when adolescent boys consider gender and its role in science and science education. In their masculine discourse, boys rationalised their gender stereotyping of activities by implying that girls don't want to see, and are uncomfortable with images that are not feminine. They buy into imagery of femininity and masculinity to which they have become accustomed through social interaction, and to which they have attached meaning in constructing their masculinity. They also rationalize their gender stereotyping by implying that girls are inferior as regards physical strength, facing fear and confronting unpleasant environments.

Whilst there are a few girls who alluded to physicality as a reason for men's being more suited for careers in applied science careers, it would appear that, in offering reasons for ascribing careers or tasks to men rather than women and vice versa, girls substantiated their views based on emotional/psychological differences. Most of the boys based their gender stereotyping more on physical attributes.

7.2.2 Intellectual

Boys and girls also use perceived intellectual superiority as a basis for comparing each other's suitability for tasks or careers. These perceptions are reflected in comments that boys are better at understanding things than girls (my emphasis):

GADIJA (G7F02): *The **mindset** is different, …girls follow female careers …they do female jobs…*

CHRISTELLE (G7F04): *Mothers **know** more things about babies than what fathers do…*

SUMAYA (G8F08): *But boys and men are better at cars, they **understand** cars better also… Men understand the body more…*

CLINT (G7M02): *…the females aren't as **smart** as the men…*

A response by one of the Grade 7 girls, that the 'mindset' is different between girls and boys, sets the scene for boys' and girls' distinguishing between the sexes on the grounds of the way in which they think. This view echoes one expressed by a student in Fiona McDonnell's qualitative study (McDonnell, 2005), which she undertook in order to understand the images of physics and physicists held by high school physics students. In her response to the question as to why she did not intend pursuing a physics career, the female student indicated, "No, I'm definitely not the right sort …it has to do with the brain, the way you think…. No, I'm not the right sort, I don't have a beard." (McDonnell, 2005, p.585). These perceptions have their origin in the ongoing debate emanating from the reported differences in the physiological features of male and female brains and the effects that these might have on men and women's behaviour, actions and performance, particularly with regard to science. In view of this debate, Valian (2005, p.1), as reported by Anger and Chang in the *New York Times* article 'Battles of sexes whirls above science gap' (included in *Sunday Times* supplement, February 6, 2005), acknowledges the existence of physiological differences between the brains of men and women:

> "We can't get anywhere denying that there are neurological and hormonal differences between males and females, because there clearly are."

In the same article, Valian is further quoted as saying that "the trouble we have as scientists is in assessing their significance to real-life performance" (Valian, 2005, p.1). The debate stems from, and is in reaction to, a view expressed by Harvard University president, Lawrence Summers, that one of the factors in describing women's sluggish progress in science and mathematics might be "innate differences between the sexes" (Valian, 2005, p.1) and intrinsic gender differences (McDonnell, 2005). As part of the growing body of research into the physiological differences between male and female brains, Witelson et al. (1995) contend that women have a greater density of neurons in the

posterior temporal cortex of the brain. The questions being asked, which remain the focus of debate, is how this affects thinking and behaviour, and whether the perceived differences in thinking, behaviour and performance can be ascribed to the physiological differences. Valian, a psychology professor, ascribes boys' and girls' thinking about male and female roles in society to males' accumulation of advantage in society and gender schemas that are cognitive in origin, where gender schemas are "hypothesis about what it means to be male or female, hypothesis that all people share, male and female alike" (Valian in Ceci & Williams, 2006, p.32). McDonnell contends, however, that the cognitive differences model that describes the innate cognitive gender differences between the sexes:

> "...ignores the socio-cultural dimensions of physics and how those contexts shape the different choices people make with respect to decisions about continuation in science or selection of an appropriate field of study within science." (McDonnell, 2005, p.583)

This thesis supports the view of the integral, essential and contributory role that socio-cultural factors play in learners' development of gender schemas and stereotypes.

In using intellectual attributes on which to base differences in gendered roles in society, the girls' responses did not contain the same kind of negative terminology that the boys used. Their comparisons were positive of both genders.

In the context of 'hegemonic masculinity', the utility of science is aptly described in *Collier's Encyclopedia* (Halsey and Friedman, 1984, p.498F):

> "...Science was seen as a key to power over nature, and to power over other nations."

This utility of science to facilitate power and supremacy provides a context for and establishes a connection between science and the authoritative, 'hegemonic' kind of masculinity of which Connell (2007) speaks. This definition of science, and the gender stereotyped profile that has been built up around it, fit comfortably into the mould of the 'hegemonic masculinity'. The masculine image of science manifests itself in science laboratories, classrooms and workplaces in the form of gender stereotypical perceptions and attitudes that scientists, learners and workers have in society, and specifically in male-dominated science careers. Frosh et al. (2002) are of the opinion that schools, where learners socialise and engage with the curriculum, provide a key site where masculinities are constructed and endorsed through the socio-cultural transference of the 'science' gender schemas that society has formed. Swain (2003), in his study of the role of the body in the construction of masculinities amongst young learners, finds that the young boy's body plays a key role, especially in social interaction in peer groups, in constructing his masculinity. Swain (2003) labels the body a social symbol that boy learners use as a tool to relay messages about their masculinity, and states

further that the construction of masculinity via the peer group is a collective enterprise. In the conclusions that Swain (2003, p.311) draws from his research he states that:

> "Bodies are used to classify boys in the formal school culture and in the informal pupil peer groups, and the main argument in this paper is that boys use the somatic body as the main source to construct their masculinity. …the body forms a major constituent of dominant and subordinated forms of masculinity."

In establishing a link between power and gender, reference was made in Chapter Two of this thesis to Bonthuys and Albertyn's (2007) allusion to the power differences innate in gender, and how these translate into teachers' having micro-manipulative power (Scantlebury, 1998) over learners' grades, curricular choices and other classroom dynamics in science classrooms. This is aside from teachers' bringing into these classrooms their own, gendered, stereotypical views on the role of women in science and science education. Harding's comment (1996, p.14), cited earlier in this research, is that the image of science's being "in a masculine straightjacket" finds expression in school science classrooms and playgrounds, in the way that boy learners 'live out' their masculinities. The manner in which boys construct their masculinities in the context of hegemony and power thus ties in with the masculine image of science and the endorsement and perpetuation of that image in society, through culture and socialisation, for the next generation to emulate. Harding sums up the debate aptly when she says that:

> "For one thing, the very same personality traits that young males must take on to become masculine in the modern West are just those that are particularly valued for careers in science and related fields. Facility in abstract thought, physical interaction with the environment, and a conception of nature as separate and in need of control – which parents and the society encourage in male children in order to make them more manly – are just what prepares young people to like and excel at math, science and engineering. Correctively, in order to make female children feminine and womanly, parents encourage a tendency toward concrete and relational thought and a preference for personal and caring service to other people. These traits prepare girls and women to prefer teaching, mothering, and other service and caring activities to those that are essential for careers in mathematics, science and engineering."
> (Harding, 1991, pp.28-29)

7.2.3 Roles

The implied skills level that boys and girls ascribe to each other as a means of gender-based differentiating of the suitability for certain tasks or careers is related to intellectual capability and refers specifically to the talents that boys and girls exhibit in performing certain tasks. The ability to perform in particular activities like applied science or caring for infants, because of perceived skill levels, forms the basis of the gender stereotyping of certain roles (emphasis mine):

AMINA (G7F01): *The boys are **more practical** and like cars…*

JEAN (G7F06): *…mothers are born with the **natural instinct** to nurture, care for babies. When they have a child, they know what to do with the baby…*

ZAINAB (G8F09): *...like, they take **better care** of the child, they know when it want [sic] to eat and stuff like that...*

PETER G9M11: *Er, I don't think that's [girls' becoming car mechanics] about the girls because mostly men are good **with their hands**, that's how I feel about that...*

In an explanation of the perceptions of gendered differences in skills or talents, Valian (2005, p.2) feels that the assumption of gender-based differences in talents and skills is questionable and that it is rather a matter of the deficiencies in the way in which we nourish the different skills that enables perceived, gendered differences to become apparent. The manner in which men and women's roles in specific tasks is constructed in society is 'learnt' by girls and boys and is expressed in their views about these roles – further establishing and entrenching the stereotype for other generations of boys and girls to emulate.

There are certain tasks or careers that girls and boys feel are more suited for a particular gender because of the perceived emotional, affective qualities that those tasks or careers require and that they believe this gender possesses. Women, being the gender solely able to give birth because of their reproductive physiology, and because of their singular physiological potential for continued sustenance, nurturing and care after birth by virtue of being able to breastfeed, are uppermost in learners' minds when it comes to childcare. Their unique reproductive physiology forms the basis for the stereotypical perception of women's being better able to care for babies and infants. This perception connects to and strengthens the link of the female stereotype with affective science careers like nursing. The perception came strongly to the fore in the responses of the learners in the in-depth interviews, as shown in these examples (emphasis mine):

CHRISTELLE (G7F04): ***Mothers know more things about babies** than what fathers do...*

JEAN (G7F06) : ***Mothers are born with the natural instinct** to nurture, care for babies. When they have a child, they know what to do with the baby...*

SUMAYA (G8F08): *I think the mother should look after the baby because **she has more of a motherly instinct,** more than a father ...uhm ...she **knows what a child needs**, more than the father...*

BRUCE (G8M05): *The woman, Sir, [should look after babies] because **the woman is nurturing**, Sir ...takes better care of the child than the dad's supposed to...*

Aside from mothers' obvious physiological connection of giving birth to and breastfeeding babies, matching mothers to roles that exhibit caring and nurturing fits the gender schema theory (Ceci and Williams, 2006; Weisgram and Bigler, 2006) that explains how learners learn what it means to be male or female. Valian (Ceci and Williams, 2006) comments that as folk psychologists we see

women as nurturing, expressive, and behaving communally owing to the gender schemas that we have built up around the gendered roles of men and women; this causes us to overrate men and underrate women. The views expressed by the learners in the in-depth interviews bear this out. Weisgram and Bigler (2006) also allude to this caring and nurturing role of women when they refer to the altruistic values that women subscribe to when considering career options. The gender schema that learners have constructed through their experience and observations in society, about women in general and their mothers in particular, is one where mothers nurture and care for babies and play the role of protector of the wellbeing of infants. The birthing experience to which learners are exposed as family members, encompassing the first sight of the mother with the baby in the hospital, breastfeeding and caring for the infant, becomes embedded in their memories and contributes to the gender schema that they build up around the role of women. The experience provides the social context for the construction of the gender schema of the role that women are expected to play and the activities in which they are expected to participate. This image is structurally supported and further entrenched by the various actions of mothers in caring for and nurturing their babies. This gender schema becomes endorsed and is perpetuated by learners in the views that they express.

The home, encompassing family life, is a significant site where pathways about gender roles are established. It is the setting where children are schooled into the societal belief system that distinguishes activities in which girls and boys are expected to be involved, such that girls are 'steered' away from science-related fields and 'initiated' into accepting domestic duty and caring and nurturing as their 'responsibility'. The learners' opinions expressed in the in-depth interviews could be linked to a continuing parental tradition of regarding the performance of domestic duties as traditionally women's work. Traditional parental roles in the home were characterised by specific tasks being done by specific genders: men went out to work whilst women attended to the children and did the housework. However, in the post-industrial revolution, as is the case currently in the homes of the learners participating in the in-depth interviews, women entered the job market. This brought into focus the question of who would do the housework and look after the children. A realignment of traditional duties ensued, yet even in this modern era, domestic duties are still regarded as 'women's work'. In society, domestic duties are also the focus of class struggle since, as women increasingly enter the workplace, there is a dichotomy: many women feel trapped by an imposed, internal struggle of engaging in the economy in the form of employment, as well as 'seeing to the house and the children'. Those women who do participate in the labour market have, in many cases, other women to do their housework. In so doing, they continue to 'enslave' other women to domestic duties and thus perpetuate the gender stereotype. 'Looking after the children' has also become an industry in itself, engaged in mostly by women. The Developing World setting, in which

sections of South African society could be included as regards the issue of women' and girls' being tied to the stereotype of domestic duty, is aptly illustrated by Nancy Gibbs when she says that:

> "Across much of the developing world, by the time she is 12, a girl is tending house, cooking and cleaning." (*Time Magazine*, February 14, 2011)

The discussion with the learners about housework relates to this debate concerning women and domestic duties. It attempts to establish the social patterns and the thinking around tasks in the home and the extent to which these tasks are ascribed to particular genders. A comment by one of the girls in the in-depth interviews sums up the status quo for most of the learners who participated in this research:

GADIJA (G7F02): *Women are at home, most are at home …but there are instances where men are at home but still mothers must come and clean the house …men don't know what women go through. She must look after the children, clean the house… It goes both ways… [learner very excited]*

The statement about whether boys should do housework was qualified by mentioning specific tasks like cleaning and cooking in order to attach a traditionally feminine characteristic to them, so as to establish whether the responses from girls or boys would have a gender stereotypical bias. Most of the learners responded, with some qualifications, that housework should be shared. Responses such as:

RUWAYDA (G7F03): *I think men should help around the house, housework is not only for women and housework is about cleanliness…*

GRAHAM (G9M10): *Yes, I think so, they should help their mother and their sisters because you can't let them do all the work…*

reflect the feelings of most of the learners. The above Grade 7 boy's response that "housework is about cleanliness" showed a cognitive ability to transcend the content of the debate about whether it is a man's or a woman's job, removing the gender aspect and focusing on the central purpose of the work, which is cleanliness of the house. One of the boys felt that the type of housework mentioned was in order for boys to do but that:

ROBERT (G7M03): *…men have to work all day and if they come home then the house must be clean…*

indicating a clear, gender stereotyped expectation that it is a wife's duty to do the housework whilst the man 'goes out to work'. Another boy felt that

TERENCE (G7M04): *Yes …some men is lazy or they don't want to work in the house…*

and implied that men should get involved in the housework.

A few boys expressed the opinion that men have to do the "harder, outside work with their hands" and women should do the softer tasks, like cleaning and cooking. Whilst acknowledging that the duties should be shared, this remains a gendered, stereotypical perception and subscribes to the widely held belief of especially the boy learners in this research, in the perceived physical superiority of men over women, once again buying into the idea of 'superior' physicality being a symbol of masculinity. The following boys' responses epitomise the opinions of boys who subscribe to the above comment:

LANCE (G9M09): *...the men will do the harder work cause the women, uh, the women, will do like the dishes, 'cause the women are not, not as strong as men are, OK...*

ROWAN (G8M07): *Yes, Sir, I think they [men] should help around the house ...but the, uhm, more of the hard stuff ...and the ladies should do, uhm, .less hard work...*

Many of the boys mentioned that their fathers assist in the house. This again reflects a connection between the learners' opinions and social reality, their lived experience, where they see their fathers do these specific household tasks. The connection between 'hard' work with your hands being more for men than women, is a repetition of responses to the question of whether girls should become car mechanics. It similarly connects to the perceived superior physical strength of men over women, again alluding to a stereotypical perception of work which is suited to a gender because of perceived inadequacies of that gender. This a common theme surfaced also when questions relating to scientists, automotive mechanics and medical doctors were discussed. Once again, from the majority of the opinions of the girls as compared to the boys, it appears that the girls have moved beyond the stereotypical gendered perception that housework is a female preserve. This phenomenon of boys' being stuck in their stereotyped notions of the role of girls, especially concerning domestic duties, and of girls' moving on, away from the stereotype, is aptly summarised by Freeman (2004, p.17) in her comment:

> "While many boys retain the old-fashioned notions of the male headed family with mothers at home caring for the children, girls' attitudes have changed: they are less attracted by a man as a meal-ticket and more attracted to having a career of their own."

The caring for and nurturing of babies and younger children is a task traditionally ascribed to women. Learners were engaged in a discussion to establish the patterns of childcare in the home and to determine to what extent the assigning of tasks and activities was gendered. In answer to the question as to who should look after babies when a parent goes out to work, 85% of all the respondents across grades and gender were of the opinion that it was the mother's task:

GADIJA (G7F02): *...mother is more responsible, she is more attached to the baby than what the father is...*

RUWAYDA (G7F03): *I think a mother connection is closer to a baby than a father. Mothers are more affectionate and caring…*

Girl learners' use of terms like "more responsible", "more attached", "more affectionate and caring" indicates that girls ascribe enhanced qualities to mothers when nurturing of and caring for infants are discussed, pointing to a clear bias and gender stereotyping of the role. The language and vocabulary that girls are using to express their viewpoints are indicative of their entering a mode of femininity, espousing affective qualities that are normally ascribed to women. The use of the word "more" prior to the words "responsible", "attached", "affectionate" and "caring" denotes an enhanced status and additional qualities of being morally accountable and trustworthy, devoted, emotionally capable and protective when the task of looking after babies is mentioned. Being girls and potential mothers, one could expect that they have a natural predisposition towards the view that mothers should care for babies. It appears that they have been, and continue to be, prepared for this role. It also needs to be stated that, in all probability, the social reality and real life experience of the girls and boys who participated in this research is that their mothers care for and nurture their siblings or babies in their nuclear or extended family. A characteristic of the learners' opinions is an acceptance that mothers were somehow imbued with an innate ability to nurture babies. This response was not unexpected seeing as mothers give birth to babies: that, together with the potential to breastfeed, seals their caring and nurturing 'fate' and brings them naturally closer to the rearing of children. In addition, the societal construction of the mother's role as caregiver and nurturer appears to have the effect of cementing the gender stereotype. It would appear that the more closely activities relate to the mother's giving birth to a child, the more gender stereotyped the opinions about the activity become. Learners' stereotyped perception of these 'nurturing' activities is firmly established; most believe they are the role of the mother. Only three boys and one girl were of the opinion that both parents should share the tasks, for example:

QUARNITA (G7F05): *Mothers are not the only parents – fathers need to help and take responsibility…*

ACHMAT (G8M06): *I think both [parents] must …he [baby] must create a bond with his father and with his mother…*

It would appear that this gendered, stereotypical opinion is strongly embedded in both boys and girls. Aside from the learners' opinions reflecting the social reality, other strands can be picked up for the origin of this opinion. One of these strands could be the way in which boys and girls are socialised and the culture in which children are raised to accept looking after infants as the task of a woman. Girl children are traditionally given dolls and feminine toys to play with and are thus socialised from an early age that they are the ones who look after babies. Giving boys female dolls to

play with is generally frowned upon in society; this embeds the stereotype of women's looking after babies and reinforces the view that women are nurturers and have more of an affective quality associated with their role in society and in the workplace. The role of caring for infants is thus socially constructed. This view links with the comment by Jones et al. (2000) that the participation of girls in science is influenced by the connectivity of that science to their socio-cultural experiences. It supports the view that where women are involved in science, science education and applied science careers, they are biased towards the affective sciences, where caring and nurturing are a feature of the science. Zohar and Sela (2003) comment that this type of science involvement facilitates girl learners' need to connect to their life experiences. Nevertheless, the stereotype of its being a traditionally female task to look after babies is still strong amongst both boys and girls.

7.3 Gendered notions of careers

One of the key themes emerging in the interviews was the way in which learners continue to gender careers in general and science-related careers in particular. It was evident in the interviews that for the most part, participants' observations of human activity lead them to associate a particular gender with a specific human activity and to construct stereotypes around such specific roles and activities in society. This gender stereotyping of roles in society reveals the extent to which learners have internalised the values, norms and traditions of the society in which they are socialised. Society's construction of these stereotypes leads learners to regard and accept them as a reality in society. Learners' use of gender stereotyping is thus a manifestation of the internalisation and confirmation of the transference of societal values, norms and traditions regarding perceptions of science and science education.

Social Constructionism contends that learners, through reflecting on their experiences in society, develop certain constructs about which genders traditionally perform certain tasks in society. Learners make sense of what they see happening in society. This understanding that they develop constitutes their knowledge about gender-specific tasks (Orey, 2001; Roychoudhury, Tippins and Nichols, 1995; Shaw, 1995). The construction of their knowledge about gender and careers is thus a social process in which language plays an integral part as a tool for interpreting and reflecting on what they experience, and culture presents the backdrop and the context for the construction of this knowledge. The extent to which learners' cultural context impacts on their understanding of the role of gender in science and science education is investigated in the face-to-face, in-depth interviews.

The careers presented to the learners in the in-depth interviews could be categorised as science and non-science careers (learners had more knowledge of and social contact with the latter). As a way of exploring the gendering of science careers, learners were asked to express themselves

regarding why more boys than girls appear to be following science careers. In their responses to statements the boys used perceived greater male physical strength as one of the reasons to substantiate their gender stereotypical perception that certain careers are more suited to boys than girls. The boys' reference to physical strength as a reason exposes the way in which their masculinity has been constructed in society: it is the 'currency' prevalent in that social class that forms the basis of distinguishing what should be suitable for boys and for girls, and also the manner in which boys express their masculinity by comparison with girls. In this respect, Frosh et al., in commenting on the various ways in which aspects of masculinity is expressed, state that the "ways in which boys position themselves in relation to masculinities is a complex process which is cross-cut by social class" and that this process is "deeply embedded as a mode of regulation of boys' identities and relationships" (Frosh et al., 2002, p.98). In this respect, boys in the in-depth interviews made comments as indicated below when they were asked about girls taking up a career like automotive mechanics:

CLINT (G7M02): *Maybe 'cause it's harder. It puts strain on your body ...and females don't like to do that stuff ...they like to sit and work in an office and do small stuff like that...*

TERENCE (G7M04): *...because women don't like heavy work like to do experiments. They don't like their hands to get dirty. Whereas men like to do experiments...*

ACHMAT (G8M06): *Boys go for physical stuff ...like ...because that's all very physical...*

In taking up this issue of the role of physical strength in gender stereotyping, Jeff Hearn (2007, p.22) asserts that:

> "Men are in formal power in business, politics, government, the military, religious organizations, and so on. Men are dominant in ownership and control of resources, resource accumulation, and the reproduction of socio-economic inequalities."

The above excerpt provides the context for the general belief in society that men are more powerful than women because of their control over resources and access to power. This same bias about the role of women with regard to specific tasks comes through in the boys' comments in the in-depth interviews in this research. The drawback that women face as a result of their disadvantaged position in power relations creates the environment for the belief that women should avoid engaging in activities and careers that are demanding, and that somehow it is not 'feminine' for women to do so. Some of the girls' comments in the in-depth interviews bear this out.

Other comments by boys expose another theme that alludes to different, gendered interests that boys and girls have and that are constructed as inevitable in society. This theme points to the binaristic construction of gender in relation to science: that both girls and boys are 'naturally' interested in different things in science because of their gender. The comments below point to this:

ROBERT (G7M03): *Girls don't like science and boys like science.*

BRUCE (G8M05): '*Cause they …maybe they think it's more feminine to do other things, Sir. That's more in their group …in their priorities*

ROWAN (G8M07): '*Cause boys are more interested in like science and gadgets …interested in taking careers like science…*

GRAHAM (G9M10): *I don't think girls are …into chemicals and formulas…*

Boy learners' buying into the belief system that men are more powerful than women, as indicated by the excerpts from the in-depth interviews below, appears to pre-dispose them to a perception that girls should be interested in activities and careers that fit their (the boys') way of thinking. This has the effect of building up expectations in them of what girls' interests in that direction should be.

JOEY (G7M01): *…boys work is outside the house. We are better with our hands…*
Men are like…rough…rough. They [girls] don't want to like work with blood and things…

CLINT (G7M02): *…'cause it's [work of automotive mechanics] hard. It puts a strain on your body. …females don't like to do that stuff…*

ROBERT (G7M03): *…they don't like to work [on] cars …they scared their fingers and stuff's gonna break…*

TERENCE (G7M04): *…they don't have the muscles that men have…*
…women don't like heavy work…

ACHMAT (G8M06): *They [girls] really gonna have a problem …like the stuff is too heavy…*
Boys go for physical stuff…

Girl learners' interests are thus pigeon-holed into gender stereotyped categories that are characterised by what 'suits' their perceived gender capabilities. Societal belief systems, with concomitant and affirming socially accepted practices, are built up. Boys and girls feed into this way of thinking by expressing typical views and acting accordingly in support of them.

From the participants' comments, it is also evident that they are influenced by popular constructions of gender highlighting the power of the media, for example:

UTHMAAN (G8M08): *I think boys see more, uhm, like on TV and on, in magazines that there are more, uhm, male scientists than female scientists, so it will be more than, more like boys' thing instead of girls'…*

THABISO (G9M12): *Well, I think the reason for them not following in science careers might be that they believe that they won't make it 'cause what they see in the media and what they see all around is that you don't get a lot of female scientists, they not sure that they will make it…*

The above boys' comments establishes a connection between the popular media and learners' perceptions of science and science education and point to the powerful impact that the media has in formulating and affirming opinions and perpetuating gender stereotyping in science and science education.

Girls similarly presented a deterministic view on girls' relationship to science. They spoke of perceived intellectual and other deficiencies, weaknesses, dislikes and shortcomings in girls that indicate a gendered, stereotypical viewpoint centering around stereotypical versions of femininity:

RUWAYDA (G7F03): *Maybe they don't like to work with blood and it's hard for girls to deal with blood... Boys don't mind getting dirty...*

SUMAYA (G8F08): *...because they would rather do ...more female role, like traditional values ...women in the family follow what the grandmothers and great-grandmothers followed, nurses or so...*
They [boys] think they understand it better.... [laughs]

It appears that the science workplace is a male space not to be entered into by girls and girls are diverting their interest for fear of being seen to challenge the hegemonic system that they perceive as male-dominated, as evidenced by one of the participants' comments:

LEBOGANG (G9F11): *They [girls] don't take an interest in science. ...They don't want to challenge the industry ...uhm ...it's a male-dominated industry.*

There is also a perception amongst some girl participants that girls have accepted an intellectually and academically inferior role and that this has developed into a mindset that channels their thinking into what society expects of them, as portrayed by the comments of the following girls:

KAREN (G9F13): *In their minds they think it's for males, they cannot achieve that.*

GADIJA (G7F02): *The mindset is different, most of the girls follow a female career.*

The above-mentioned opinions expressed by some of the girls represent one side of the status quo with regard to girls' perceptions of the 'gender in science and science education' debate. It points towards a number of the girls seemingly aware of socially constructed perceptions of their being physically weaker than boys; seeing it as inevitable that they will be perceived as such; and then reverting to this socially accepted, 'fall-back' position when a situation they are in or have to comment upon, challenges the popular belief system that boys are 'superior' to girls. Some of the comments used by the girls contain phrases like "traditional values that women in the family follow" and "grandmothers and grandfathers" that relate to the past and practices located in the past. These phrases epitomise the age-old, socially accepted belief system of perceived men's superiority. They provide evidence of the link to social, stereotypical myths and societal pathways that have been laid

down through generations and which constitute society's 'institutional memory' regarding gender. In alluding to these social traditions that have been passed down, Ampofo and Boateng (2007, p.57) refer to the reproduction of "the modern myth" of the male provider and breadwinner. This view is further substantiated by the learners' use of comments that "they don't want to challenge the industry" and "the mindset is different". These comments perpetuate a belief system that boys draw on and that almost coerces girls into a mode of thinking that says, "Go back to your social stereotype and the status where you belong and don't leave the pathways that have been laid down by generations before you". They also highlight how girls resist entering traditionally male-dominated careers as they know that it will be a challenge for them. Learners' responses confirmed the research findings of Andre (1999) that learners regarded jobs in science as more male-dominated – this seems to have added to girls' resistance to these careers.

Two of the learners (a girl and a boy) commented that boys become interested in science careers from an early age, which connects to the construction of children's reality via socialisation, including play with toys (cars in the case of boys and dolls in the case of girls) and interaction with images of gendered, stereotypical role models.

Learners' responses to more traditionally gendered careers like working on cars or dress design were more clear-cut, from a gender stereotype point of view, than those that related to a science careers specifically. It might be that the use of the term 'scientist' was too vague a career description and that they do not have a clear understanding of what a scientist does. This issue is followed up later on in the research. The responses of the boys to the question of whether girls can become car mechanics showed a marked difference to those of the girls. The boys stuck to the stereotype that such jobs are for men only. Where their responses did 'allow' for girls to pursue the career, it was with perceived shortcomings and doubts about physical strength or level of skill. Four of the 12 boys expressed the opinion that girls could become car mechanics but had reservations ranging from:

ACHMAT (G8M06): *I think it's OK but I don't think they really gonna... They gonna have a problem... It's difficult stuff in there...*

BRUCE (G8M05): *...sounds a little bit weird, Sir...anybody can become what they want... but still ....it's a man's job to do mechanics...*

THABISO (G9M12): *It's not really, not really common for girls to become car mechanics...*

Particular phrases like "it's OK but", "sounds a little bit weird", "not really common" and "still a man's job" point towards some boys' reservations about the wisdom of letting girls do a 'man's job' and difficulty accepting possible changes to a societal belief system. It indicates a 'yes, but' attitude

and a view that, where instances of a woman doing a 'man's job' do occur, they are an exception to the rule. Their responses reflect a stereotypical viewpoint and connect to a particular mindset and pre-existing pathways of thinking and behaving according to a system of male domination. Thus, while they know it is no longer politically correct to say girls cannot do something, they have reservations centering around traditional notions of what boys and girls are like, and/or can be.

Two boys responded positively and without reservations that girls can become car mechanics. The other six male respondents all felt that the activity was definitely not for girls, for reasons of perceived physical and intellectual challenges that such an applied science career would have for girls. Their opinions that:

LANCE (G9M09):	*...girls are more feminine, ...most of them won't touch stuff that are dirty.*
GRAHAM (G9M10):	*[laughs] I think they can't do that, I don't think they qualified...*
PETER (G9M11):	*I won't trust a girl to do a man's job.*
CLINT (G7M02):	*I think they're confused, cause girls don't ...mustn't become mechanics...*
ROBERT (G7M03):	*No, they can't make cars right, because they don't know what's going on there...*

indicate a rejection of the concept of girls' pursuing the career. Responses like "girls are more feminine", "I don't think they qualified", "I won't trust a girl", "I think they confused" and "they don't know" conjure up images of a lack of faith in girls' abilities and skills and manifest a view that it goes against a popular societal belief system to have girls pursuing that career.

This phenomenon of adhering to a gender stereotype for a particular career is common for certain careers that are traditionally deemed suited to a particular gender because of perceived strengths and deficiencies. This kind of gender stereotyping of careers has its origin in and before the Industrial Revolution till the emergence of women onto the job market, which had previously been occupied by mostly males. Sharon Kleinman (1998) comments that the perceived physical and intellectual inferiority of girls is the reason proffered for the disparities in participation rates of girls and boys in science careers and for science's being viewed as a male domain. It appears that the stereotype attached to the job of being a mechanic is still strong in the boys, whereas it appears to be weakening somewhat amongst the girls.

It needs to be pointed out that, in the communities in which the participants are based, girls as car mechanics are not in evidence in the lived experience of boys or girls; it is not part of their social reality to see women in such roles. There aren't many female car mechanics in the mechanical and automotive engineering industry and the images in the popular media do not portray girls doing

the job. Therefore, the image of girls participating in the activity has not been constructed in society to the extent that it is a familiar sight to boys and girls. Whilst this media portrayal has impacted on boys and girls, the female participants hold a significantly stronger view that girls can become car mechanics (see analysis of girls' responses).

Similarly, when looking at more specific applied science careers, like that of medical doctors, the boys' responses again confirm gendered, stereotypical views that the men are more suited to being medical doctors. The reasons proffered point towards perceived intellectual, physical, emotional and skills inadequacies on the part of women. Comments made by the boys included:

ROBERT (G7M03): *Because they [men] know more stuff than women…*

CLINT (G7M02): *…the females aren't as smart as the men ….uhm …that's all.*

PETER (G9M11): *I think it's because maybe the men can put more effort into what they want to do …and I feel that the man is stronger enough to do a doctor's job.*

BRUCE (G8M05):… *…because the women …er …they, they stress very quick, Sir.*

ACHMAT (G8M06): *…Because …er …the males find it easy, …er …they're kind of used to the stuff…*

ROWAN (G8M07): *…because men is more interested in that …'Cause it also …also involves science …and is more of a man kind of thing…*

The boys' use of phrases like "know more stuff", "aren't as smart", "males find it easy" refer to intellectual capacity. They show that they perceive males to be more intelligent than girls. Boys also use phrases like "[girls] don't like to work with blood" and "the man is stronger" that indicate that they subscribe to the view that men are physically stronger than women. In referring to "rude patients" and the stress of the job, they buy into the perception that men are emotionally stronger than women. There is the perception that men are 'tough' and somehow more able to withstand the rigors of the job. These comments confirm the boys' gendered, stereotypical perceptions that there appear to be more male medical doctors than female doctors and that men are more suited to a science career. The boys' stereotypical views are similar to those expressed for other careers and point to a generally stereotypical view of matching genders with careers.

The responses of the girls with respect to medical science were more varied. 53% of the girls' views were similar to the boys' and adhered to the gendered stereotype for the career. In their comments these girls expressed doubts about the capabilities of girls to pursue the career. They regard the career as mostly a male preserve and made comments like:

GADIJA (G7F02): *..more men are into the doctor thing…*

RUWAYDA (G7F03): *Maybe they don't like to work with blood and it's hard for girls to deal with death...*

SANDRA (G9F12): *...they think it's a male-dominated career...*

In their responses some of the girls used similar terms to those of the boys as to why there appear to be more male than female medical doctors. They referred to physical aspects like dealing with blood and emotional aspects like dealing with death to support their views that girls are not suited for the job. They again expressed the view that it is a male-dominated career, which shows their negative attitude to women's being in the profession.

Learners were also asked to express their opinions as to whether boys would want to become dress designers to ascertain their views on what could traditionally have been seen as a female pursuit because of its direct relation to female apparel, the dress. 75% of the boys and 14% of the girls confirmed the gendered stereotype that the career is one suited for women, and were of the opinion that boys would not want to become dress designers since it was a female pursuit. Three of the boys' responses sum up the attitude and perceptions of boys on the matter of dress designing as a career option for boys to follow:

TERENCE (G7M04): *No ...no, because they, they think that making girls' clothes is not something nice to them...*

ROWAN (G8M07): *Not ...uhm....not really ...'cause it's more like of ...er ...a lady thing...*

UTHMAAN (G8M08): *I don't think so because ...I think at a young age ...they realise that it's more for women and their friends tell them no, they shouldn't do it because its like it's like more girlish than for boys....*

The boys' use of the phrases "not something nice to them [boys]", "a lady thing" and "it's like more girlish" indicate a social uneasiness associated with boys' following a career perceived as more fitting for a woman. Their responses also indicate that there is social pressure on girls and boys to conform to a career that is traditionally one perceived as being for a specific gender.

Some learners who felt that dress designing was a female pursuit made a connection between men dress designers and being gay as their reason for boys not wanting to become dress designers, highlighting how homophobia and the importance of distancing oneself from homosexuality is an imperative for young men (see, for example, Shefer, Stevens and Clowes, 2010). Some of the learners interviewed had this to say about boys who would want to become dress designers:

ROBERT (G7M03): *No, because ...if they make clothes they gonna think they're gay...*

BRUCE (G8M05): *No ...because they think you're gay and think those kinda things...*

LANCE (G9M09): *...it's mostly the men that wants to look like ladies, who, that will do that kind of work, that wants to ...be like a lady, they will do that type of work.*

LEBOGANG (G9F11): *...people who, most of them who are gay become male dress designers...*

CATHY (G9F14): *No, well the boys I know...uhm ...if they are male, they are stereotyped as gay. So I don't think so...*

The learners make a connection between becoming a dress designer and being gay and this is evident in their use of phrases like "they gonna think they're gay", "they think you're gay", "the men that wants to look like ladies", "who are gay become male dress designers" and "if they are male, they are stereotyped as gay." In referring to the gay stereotype, learners are attaching the idea of boys' pursuing the dress designing career to something that boys are not expected by society to be; were they to be doing so, they would be displaying feminine behaviour that boys are not expected by society to exhibit. Learners are clearly aware of gender stereotyping and of the apparent social stigma attached to pursuing careers that are traditionally identified as being for a specific gender. Again, it is evident that social pressure, and specifically peer pressure, have a strong influence on learners' conforming to society's expectations for masculine and feminine behaviour, also in the type of career that one pursues. Frosh et al. (2002, p.175) note the frequency with which this phenomenon of boys' entering a career or participating in actions traditionally 'reserved' for women, leads to their being labeled as gay, is apparent and conclude that for boys:

> "...homophobia is seen as a set of activities through which they publicly and repetitively assert their 'normal' masculinity through heterosexuality."

Swain (2003) encountered similar comments from the boys in the schools where he did his research on how boys construct their masculinity – the boys constructed their masculinity in contrast to femininity. It would appear that the fear of being seen as effeminate or gay spurs them on to expressing 'macho' masculine opinions. He comments that:

> "Indeed, the dominant bodies were inevitably heterosexual bodies, for masculinity and heterosexuality are entwined and to be a 'real' boy (or girl) is to be heterosexual."
> Swain (2003, p.309)

In their findings, Frosh et al. (2002, p.10) identifiy major "canonical narratives" about masculinity, one of which is that:

> "1. Boys must maintain their difference from girls (and so avoid doing anything that is seen as the kind of thing girls do)."

There are some learners, mostly girls (86%), who had no qualms about boys' becoming dress designers, indicating that girls are moving away from the idea of dress design as a female

stereotyped career, again highlighting the apparent flexibility of girls with regard to careers that are traditionally stereotyped. They comment that:

CLINT (G7M02): *There's nothing wrong with it…*

GADIJA (G7F02): *…firstly fashion used to be mostly a woman thing …if a boy wants to go into designing I would support that person.*

CHRISTELLE (G7F04): *…anyone can become what they want to.*

RUKAYA (G8F10): *I think so, yes, I see on TV how men are dress designers…*

SANDRA (G9F12): *I think yes, they can do whatever they want to, it's up to them…*

The responses of these girls and some boys indicate again that increasingly, predominantly girls are challenging the gender stereotyping of careers, even more explicitly in this case, where there is clear reference to the career's being connected to women because of its direct reference to female apparel. The use of phrases like "nothing wrong", "I would support that", "do whatever they like" expresses strong views on boys' pursuing careers that have been gender stereotyped for girls only. One of the girls' references to the media once again points to the role of the media in influencing young people's thinking regarding gender stereotypes. Also, the kind of language used by the girls ("they can do whatever they want to" and "firstly fashion used to be a woman thing") shows again that girls' departure from the gender stereotype is evidence of the influence and effect that women's empowerment rhetoric is having on the way that girls express themselves regarding gender and the workplace.

The contrast in the responses of the boys and the girls to this statement of boys' becoming dress designers once again confirms a higher level of acceptance on the part of girls of the opposite gender's participation in careers that are traditionally considered to be gender-specific. This indication that there is a weakening of gender-specific stereotypical images amongst adolescent girls, and that there is a sense in which they are 'moving on' and challenging perceptions of gender stereotyping in the workplace, are key aspects of the overall research findings of this study.

7.4 School and classroom dynamics

The actions of learners' and their peers and teachers contribute to the construction of learner understanding and knowledge about the role of gender in science education. The way in which teachers present gender issues in science classrooms has a decisive influence on their learners' opinions and actions regarding these issues (Clair, 1995; Jones & Wheatley, 1990; Ritchie, 2002; Tobin et al., 1990). The learners' responses to the statement of whether a male or female is

preferred as a science teacher were mixed, with 54% preferring a female to a male science teacher. The reasons forwarded in this slightly larger percentage are varied and do not appear to express a preference based on gender or stereotype. Dee (2006, p.70) suggests that:

> "Studies have not focused on young adolescents, the time when students are particularly sensitive to gender differences and when gender gaps in achievements are pronounced."

and in his research about the effect of the teacher's gender on educational outcomes he says that:

> "Simply put, girls have better educational outcomes when taught by women and boys are better off when taught by men. These findings persist..." (Dee, 2006, p.71)

The dynamics of learners' interaction in groups present a vehicle for spreading views, and leadership in these groups becomes an important aspect of how gender is perceived by young people. Interaction in groups also presents an opportunity for learners' social construction of knowledge and understanding of the role of gender in science education to be shaped. In an attempt to ascertain the leadership and dynamics of interactions prevalent between boys and girls in classrooms, a statement was put to the learners about the gender of the leaders in the class who would dominate decision-making. Thirteen (93%) of the girls indicated that girls were the decision-makers in the class. All the boys also felt that the girls were the leaders and that their opinions prevailed in decision-making in the class. In the findings of their research aimed at understanding boys in contemporary society, Frosh et al. (2002, p.104) discovered that:

> "Girls were seen by many boys as more 'mature' and adult-like than them – more serious, more committed to schoolwork and less interested in having fun and joking," and
>
> "...boys commonly saw themselves and other boys as ....academically lazy..." (Frosh et al., 2002, p.122)

In science classrooms boys thus act out and express themselves in ways that reflect the manner in which they have constructed their masculinity amidst the impact of the norms and values of the socio-cultural environment in which they were raised.

Comments from learners display the dominance of girls in leadership roles in classrooms:

GADIJA (G7F02):	*The girls are stronger, boys are playful...* *...the boy[s], they are not so confident like we are, in terms of what's right and what's wrong...*
RUWAYDA (G7F03):	*The girls, I feel have leadership qualities.... Boys take longer to make decisions...*
LEBOGANG (G9F11):	*The girls... [laughs] ...boys are playful and immature and irritating.*
ROBERT (G7M03):	*The girls are more responsible than the boys.*

THABISO (G9M12) *…more girls that was willing to take on the leadership role 'cause the guys …they prefer to …enjoy their time in class, intervals they'd rather play around than look after the class…*

It thus appears that, whilst in the domain of science, science education and science careers, there is acknowledgement across genders, of the male-dominated image and the male stereotype in these areas, boys and girls are of the opinion that girls are the leaders in, and a major influence on, general decision-making in these classrooms. Responses to questions set in the questionnaire indicated that especially Grade 9 girls do not think that boys get preferential treatment from science teachers. There is an indication, however, that girls in the lower Grades 7 and 8 differ from their more mature colleagues in Grade 9 and think that there is some favouring of boys in science classrooms. The same can be said of the Grade 7 boys.

7.5 Resistance to gendered notions of science

The comments and opinions emanating from the semi-structured, in-depth interviews have already been shown in the different themes covered here, to reveal a resistance to gender stereotypes more broadly and gendered notions of careers, in the science field specifically. Especially girls expressed views that indicate a shift in attitude against traditionally gendered notions of careers. Importantly, some girls are aware of the gender stereotypical perceptions of scientists and they expressed the need to challenge the perception:

JEAN (G7F06): *…I think I blame the parents. They have this perception that males are for this… They don't think that the female can do it. No matter what gender you are, if you want to do [it] someday you can do it…*

CHRISTELLE (G7F04) *They think they can't get in, they wrong they must just study…*

SANDRA (G9F12): *They think it's mostly for men, not girls. Apartheid is finished now… I say it is up to us to do what you want. It's not a male- or female-dominated world… uhm…*

This repudiation of the socially accepted belief system that says that boys are 'superior' points to a change in thinking on the part of some girl learners and represents the other side of the status quo. In all three of the girls' comments, they are stating the socially accepted belief system and countering it, indicating what should be happening in society. In her response, the first girl says that she "blames the parents", indicating an unacceptable situation that generations before had accepted, and pointing to a situation in homes where parents perpetuate societal belief systems and perceptions. She then counters this view with a statement that challenges the stereotype: "No matter what gender you are, if you want to do [it] someday you can." Her response that "they don't think

that the female can do it" also points to girls' challenging an accepted belief that girls are physically and intellectually inferior. The second girl's statement alludes to girls' going out and 'doing it for themselves', while the third girls' statement draws on a political discourse that argues against the social, race-based, separation system of Apartheid, which valued people based on their race, skin colour and gender. She sees gender oppression as part of Apartheid. This girl repudiates this way of thinking and points to a futuristic situation where we have "not a male- or female-dominated world". This last comment by this 14-year-old girl on the statement posed to her in the interview is particularly interesting, since it connects to Apartheid, a system that legally ended a year before she was born. Still, her comment is symbolic of the fight against a socially oppressive system, in this case the oppression of Black women by the actions emanating from societal structures based on biased perceptions and belief systems. The girl's view also connects to challenging a socially oppressive system that does not appear to be treating women equally. The portion of this girl's comment that says "it is up to us" further alludes to the activism of the women's empowerment movement and political activism in general.

Whilst the male stereotype of a scientist is still strong, some girls are questioning it. Freeman's (2004) opinion sums up what is also evident in my research findings, that whilst some girls and boys are accepting the gender stereotyping of certain activities and careers as for girls only, others, especially girls, are questioning the stereotypical perceptions of certain jobs being for males only. Freeman feels that:

> "Girls no longer suffer from the belief that brains are not sexy, while too many boys still appear stuck in the "macho" peer culture." (Freeman, 2004, p.17)

Freeman's (2004, p.17) opinion that boys still appeared to be "stuck in the macho peer culture" also holds true in the findings of their responses to the in-depth interviews done in this research. It appears that boys have not progressed much beyond the stereotypically accepted social patterns of girls' role and place in society with regard to careers, and are more focused on maintaining the stereotype.

In response to the statement about girls' becoming car mechanics, which attempted to elicit responses from the interviewees about girl's and boys' perceptions about girls' involvement in applied science careers, there was a distinct, gendered difference in the responses of girls and boys. This is a career traditionally pursued by males more than females. All 16 girls were of the opinion that girls can pursue the career. For example, they said:

> CHRISTELLE (G7F04): *I think girls can be whatever they want to be. Girls can do things that boys do...*

JEAN (G7F06): *People have that image about girls that stay at home... We were not given the opportunity to be pilots ...uhmm, so give them the opportunity. When gender equality is ...first ...it does not matter what gender you are, it [is] about how you perform.*

CATHY (G9F14): *I think it's nice because it shows there's equity in the society ...uhm ...that girls and boys now have equal rights to do whatever they want. They don't stereotype it's a male thing and a female thing.*

RUWAYDA (G7F03): *...because they think men are more capable, can do a better job than the woman, but I think they wrong, because girls can do anything that men can do.*

JEAN (G7F06): *they [women] were not granted the opportunity ...males are the doctors and females are the nurses, this is seen on TV and the movies...*

LEBOGANG (G9F11): *...laws are made so women cannot do certain stuff. ...a career dominated by men, if you just say science, you think male...*

Comments such as the above indicate a broader challenge to traditional gender roles and unequal power relations between men and women and strengthen the observation that girls' opinions are changing and that girls are questioning the perceptions. Comments like "what boys used to do", "I don't see why", "girls can be whatever they want", "it does not matter what gender you are", "not only boys can", "it is not only a man's job" allude to a stereotype in a societal belief system that some girls believe is of the past; it is being challenged and is changing to one that is less restrictive of girls' aspirations and actions. Whilst, after agreeing that girls can become car mechanics, one of the Grade 8 girls mentioned that "boys and men are better at cars, they understand cars better also", there were no other comments from the girls that alluded to the perceived physical or intellectual challenges of the career that would make it more suited to men. From the opinions of the girls it appears that they have moved beyond the stereotypical, gendered perception that the career is a male preserve.

The use of strong language like "dominated", "they are wrong", "not granted the opportunity", "laws are made" and "girls end up" indicates an anxiety and a frustration on the part of the girls at the current situation. The use of the word "they" also shows that social forces at work in that the girls feel that they have been targeted by elements in society and excluded, that who gets to pursue certain careers is a decision made by forces beyond their control. The girls' references to television, the movies and books in their responses "seen on TV and the movies" and "seen in movies and books" are further substantiation for the view that the media are complicit, as purveyors of the gender stereotype, in spreading the message to boys and girls that certain science jobs are a male domain.

The responses of the girls reveal a perceived lack of opportunity; their challenging of perceived superior male intellectual capabilities; gendered messages from the media; a perceived legal framework for stereotyping; and an awareness of stereotypes and dominance by society, as themed reasons for the gender disparity in the numbers of female versus male medical doctors, as a result of gender stereotyping. A Grade 9 girl's comment that being a medical doctor is a "career dominated by men, if you just say science, you think male" sums up the perceptions of girls regarding careers in science rather aptly – that this is what girls currently experience and that this situation is accepted by society. The responses of the girls also confirm a previous comment that it appears that girls are questioning the gendered stereotypical image of science, science education and science careers much more than boys are.

7.6 Concluding Remarks

The substance of the in-depth interviews reveals clear trends in learners' thinking about science and gender. With respect to broader opinion on gender roles and gender equality, it is evident that learners feel that general domestic duties in the home should be shared by mothers and fathers; this appears to be also because it is part of their lived reality. Whilst boys and girls, especially as they mature in age, do not appear to think that their science teachers differentiate in the attention that they apportion to either gender in class, boys' interaction in peer groups appears to reflect the accepted, stereotypical views of the role of girls and women in society. Learners have gendered notions of careers. Resistance to gendered notions of science and science education is, however, also evident in especially the opinions of girls, as they are mature in age. Girls, especially in Grade 9, are expressing opinions questioning the male orientation of science careers specifically and the gendered notions of careers in general.

In comparison with the quantified responses of the survey questionnaire, the nuances of the responses to the in-depth interviews enhanced the data about learners' views. They allowed for a deeper understanding of the influence that gender has on learners' thinking about science and science education. The meanings of learners' responses in the in-depth interviews enriched the data gathered from the survey questionnaire.

Learners' views on science were clearly shown to be influenced by gender, their own gender or their perceptions of the extent to which gender should influence the issues. The influence of the socio-cultural context, in which the construction of gender is embedded, on learners' views of science and science education was clearly evident as learners expressed their views based on the socio-economic and cultural environment of their lives in communities. It is apparent that, whilst learners construct their own reality – even if it is distorted – the different modes of 'hegemonic' masculinities

that are at play in society stem from 'ethnographic' experiences that learners have in community life. These experiences, which form the context of the construction of masculinities and femininities, include the ever-increasing influence that the media has on learners' perceptions of the role of gender in science and science education.

Despite the apparent change in the thinking of girls regarding the influence that gender should have in science (partly as a result of the rhetoric flowing from the women's empowerment movement), girls and boys are almost unanimous in their opinion that activities closely aligned to the caring for and nurturing of babies and infants should be performed by mothers. The closer one gets to women's reproductive and breastfeeding capacity, the more gendered are learners' perceptions of who should take the lead in raising children.

Whilst there was a general lack of understanding on the part of the learners of what constitutes a 'scientist' and what a scientist does, boys retained a stereotypical view of who should perform the work of scientists, also in applied science careers. Girls, however, appear to be moving away from gender stereotypical views of science careers.

Learners' opinions of non-science careers showed that socio-cultural influences were seminal – they expressed views that exhibited the effects of society and culture on their upbringing and their opinions regarding gender and science and science education.

Overall, the in-depth interviews indicated that boys, especially the younger Grade 7 boys, were more attached to the stereotypical perceptions of the tasks and careers that they think women should be pursuing. Boys appear not to regard girls as their equals and want to stick to the 'old' identities of women, despite the message from the girls that their world is changing and that they increasingly want to participate in it. As they get to Grade 9 and become older, girls appear to be moving away from the stereotypes. Grade 7 girls, to a certain extent, mirror the perceptions of the Grade 7 boys although girls, especially as they grow older and proceed to Grade 9, start questioning stereotypical perceptions regarding the roles that women play and the careers they are expected to pursue by society. The impact of the messages of the women's empowerment movement has resulted in Grade 9 girls' clearly moving away from stereotypical perceptions and becoming quite vociferous in their questioning of these perceptions and their effects in society. On this matter, it is Connell's (2007, p.vii) opinion that:

> "It took the worldwide impact of the women's liberation movement, and the many feminisms that have since developed, …to bring gender into focus as a fundamental dimension of culture, politics and economy, and therefore to bring men into focus as participants in a gender system."

The findings emerging from the in-depth interviews, particularly those pertaining to the construction of masculinities, show similarities with other research findings on the issues (Frosh et

al., 2002; Swain, 2003; Shefer et al., 2007) and confirm the indelible influence that gender has on learners' perceptions of science and science education.

CHAPTER EIGHT
Findings and conclusions

8.1 Introduction

This chapter focuses on thematically summarising the findings of the learners' responses to the qualitative and quantitative data sets and linking them to the guiding research questions of the study. It draws conclusions and aspires to make a contribution to the field of gender policymaking and the debate regarding the role of gender in science. It will show that there are commonalities and differences between the two data sets and the literature that was reviewed.

The chapter concentrates on interpreting the two sets of findings from learners' responses regarding perceptions of science and scientists and how these perceptions are influenced by their views of gender. The findings are discussed in a thematic manner to focus on the role that gender plays around the core issues of learners' science perceptions, interests and activities; gender stereotyping; science education and classroom activities; and the impact of social contexts on learners' perceptions of gender and science. Conclusions are also drawn from the findings of learners' reported perceptions of their parent's aspirations for their careers and their views of their own and the other gender's performance in science.

Inferences are drawn from learners' responses regarding their actions in the domain of science and science education, since these reflect the norms and values of their community and society as a whole, and also reflect the manner in which society views the question of gender in science. The role that gender plays in the activities, interest in, and performance of the boys and girls in the domain of science is evidenced in the analysis of the data gathered from learner responses to the survey questionnaire as well as to the in-depth interviews. The findings of the qualitative and quantitative data reveal an important trend: continued gender stereotyping is the all-important thread running through learners' actions, interest and performance in science.

8.2 Summary of findings

8.2.1 Learners' perceptions of and interest in science and science careers

There are commonalities in the findings of the qualitative and quantitative findings of learners' perceptions of, attitudes to and interest in science. Both sets of data show that learners' interest in science is gendered and that there are also gender differences between participants in their attitudes towards in science. Moreover, both sets of data show that gender stereotypes are evident with respect to the image of science, scientific tasks and science careers. Boy and girl learners are of the opinion that science is a masculine domain. The increasing strength of the boys' interest in applied science and its products is matched by an equally strong, increasing disinterest by the girls; a

comment, in the qualitative study, that an activity is “meant” for boys, reflects and complies with the gender stereotyped expectations of society. Where the focus of science interest related to activities traditionally performed by women, a greater interest was shown by the girls than the boys. There is a strengthening from Grade 7 to Grade 9 of this interest, on the part of the girls, which points to a difference from primary to secondary school and from grade to grade. This strengthening of girls’ altruistic interest in mothering and caring activities supports the opinion that the stereotypical view of the gender differences in science interest becomes more established as girls mature physically and become socially and academically more advanced, reflecting increasing pressure on them to perform in normative gendered ways. Riis’s (1991, p.114) findings reflect similar patterns of interest in such activities and she indicates that:

> “...the majority of girls ...quite firmly believe in the benevolent potentials of science”

in this adolescent period of girls’ lives. Similar indications were also evident in the findings of Weisgram and Bigler (2006, p.345) who found that where activities, including science activities, became more altruistic (arguably more ‘feminised’ in terms of traditional expectations of women) this led to increased interest amongst girls.

The gender stereotyping of activities is not limited to the field of science. In social interaction in homes, boys and girls appear to be holding on to stereotyped profiles. This study found that, in answer to the research question regarding gender differences in science activities in the home, boy and girl learners are of the opinion that boys are better at activities that have to do with science, confirming that science is regarded as a masculine domain. However, the qualitative, in-depth interviews show that, whilst there is a bias in opinions towards girls doing housework, there is a softening of this stereotype. Boys accept and girls expect that boys should be involved in activities that have to do with the care and cleanliness of the home environment. Learner involvement in science-related activities confirms the stereotypical trend where an activity was one that is generally done in any home, although some of the activities listed in the survey questionnaire appeared to be outside of the experience of, or too technical for, the learners. These trends, confirmed by data from the in-depth interviews, fit the stereotyped profiles and the gender coding in society, of boys’ enjoying fixing things and girls’ looking after babies, baking cakes and doing housework.

The responses from the survey questionnaire indicate that learners perceive science to be important for the functioning of society and for their personal lives. They know that the science that they learn in school is important and that it will help them in their daily lives. They also have a positive perception of scientists. In answer to the research question, there appears to be no difference between girls’ and boys’ opinions of the role and importance of science in society.

It is clear from learners' responses, across grades and gender, that they enjoy science, especially the products that flow from its application. Boys appear to be having a slightly more positive experience in science classrooms. Grade 7 primary school learners in this research appear to have a more positive attitude towards science. This trend has also been observed in a study with learners in Scotland, where Reid and Skryabina (2003, p.532) made the following comment in their discussion of research that they completed in the Scottish education system:

> "Towards the end of the primary school, attitudes towards science are very positive and both boys and girls are looking forward to studying more science in secondary school."

This research also shows that the positive perception of science does weaken from Grade 7 to Grade 9, such that Grade 7 girls and boys show a more positive attitude towards science than Grade 9 girls and boys. Grade 9 learners do not enjoy science as much as their Grade 7 counterparts. This waning of enjoyment reflects in their performance in science and in their anxiety levels in science classrooms and does not appear to be gendered: it is the same for boys and for girls.

Society constructs children's reality about careers via socialisation and interaction with images of gendered, stereotypical role models. In the in-depth interviews, a comment by a Grade 9 girl in response to a statement as to why it appears that scientists are mostly males, that it is a "career dominated by men, if you just say science, you think male", points to learners' understanding of current social reality in their thinking about science careers and gender.

There are commonalities in the quantitative and qualitative data regarding learners' perceptions of careers. The findings from the quantitative survey indicate that learners' perceptions of science careers are gender stereotyped. Yet findings also show that, while boys are holding onto the stereotype about science-related careers, some girls are challenging it. Similarly, the qualitative data obtained from girls in the in-depth interviews indicate their sentiment that science-related careers could be done by girls. The insistence on the part of a Grade 9 girl that girls' becoming car mechanics is positive, illustrates their resistance to gender stereotyping in science and more broadly in society. Comments such as "it shows there is equality in society, they don't stereotype" and another, with regard to girls' becoming scientists, that "first it was men [but] ...women are getting more involved ...getting more empowered" points to their emphasis on challenging gender bias and stereotyping. The differences between findings of the quantitative and qualitative data are to be found in the rhetoric, language and vocabulary that girls use in the interviews, indicating that they are aware of the issue of stereotypes and how they affect women in the workplace. The terminology and the messages of women's empowerment has reached them and conscientised them to the challenges in the struggle for women's rights. Girls appear to be more literate than the boys as to the issue of women's empowerment, especially in the workplace; there is an anxiety in their phraseology

that indicates an awareness of the issues. Boys on the other hand, in comments like “they [men] know more”, “females aren’t as smart”, “males find it easy” and “they [men] can deal with the pressure” verbalise the stereotyped, social codes for maintaining male dominance in science and science careers. In response to a direct statement about learners and their science career plans, there is a slight but growing increase in the percentage, per grade, of boys, as compared to girls, who indicated that they would enjoy being a scientist. The empowerment of girls has extended to their accepting boys entering the domain of traditionally female careers like dress designing, which further indicates that girls are questioning gendered career stereotypes in society. As they proceed from the primary to the secondary school, girls are increasingly challenging stereotypical perceptions of science careers whilst boys appear to be holding onto them and even strengthening them as they proceed from primary to secondary school.

In interpreting such findings we need to remember that learners are influenced by normative practices and existing roles in their social reality. Where they do not see women performing certain science tasks or occupying science careers, these are not in their lived experience. They may defer then to the stereotype as it is all they ‘know’, which then influences their decision-making in this respect.

As mentioned with respect to attitudes towards science, there is a noticeable trend in learner responses (especially in the in-depth interviews of the qualitative study), that where interests, activities and careers have affective characteristics, boys and girls defer to their being women’s tasks or careers. For instance, when an activity focused on childminding, the overwhelming majority of the boys and girls regarded this as a mother’s job, indicating a clear stereotypical preference. It would appear that the closer one gets to the primordial role of women’s giving birth, breast-feeding babies and caring for sick infants, the more stereotyped opinions and perceptions become of the role of women in society. This stereotyping of behaviour and parental responsibility occurs across grades and genders. It might have to do with the manner in which children are raised in society and the traditional role of women as carriers of babies in the gestation period, as those who breast-feed babies and nurture and care for infants. The learners in this research appear to adhere strongly to the image that is constructed by society and perpetuated by the media, of women as primary caregivers for children. This conventional image, confirmed in the quantitative and qualitative data in this research, is further affirmed in society by actions such as giving girls dolls and boys model cars to play and interact with. The learners’ responses in this research reflect the different gender behavioural codes for boys and girls that are normative in society and which they model; these give rise to the gender images and perceptions to which learners subscribe when they are called upon to make choices or to give opinions. The differentiated interest in science between girls and boys that

the learner responses reveal have been foregrounded by various researchers (Howes, 1998; Miller et al., 2006; Christidou, 2006) who document girls' interest in the benevolent benefits of science, the people-oriented aspects of science, and the biological, health and fitness sciences in categorising girls' interest in a particular 'brand' of science. The qualitative data indicate that, where such affective characteristics could be ascribed to an interest, activity or career, learners have exhibited this gender bias in their selection of categories of responses.

Whilst the data from the survey questionnaire of the quantitative study were corroborated and supported by data that came from the in-depth interviews of the qualitative study, a closer look at the qualitative study exposed thematic issues that formed the foundations of the learners' discourse on what makes up masculine and feminine identities and how these link with a gendered construction of science and science careers. Learners have gendered notions of careers. It would appear that they base their responses regarding the suitability of specific gender identities for specific careers on attributes like physical strength and perceived intellectual prowess.

8.2.2 Social contexts impacting on learners

In this research, the gendering of science has been used as a focal point where social variables like class, ethnicity and race conflate. Ritchie (2002), Rennie (2000), Gaskell et al. (1998) and Krockover and Shepardson (1995) feel that an understanding of these social variables, in considering girls' participation in science, is necessary for teachers. This research has accessed learners' opinions regarding gender and the perceptions of science and science education at the interaction sites of transference of these social stereotypes (parents in the home, teachers in schools, peer groups, employers and the popular media) in order to establish the current state of affairs. The overwhelming finding is that gender stereotyping in science remains in place at these interaction sites: science is regarded as a male domain. It is apparent, and this research confirms, that social stereotypes, built up over many years and ingrained by socialisation, acculturation and the institutional transference of social norms and values, continue to play an influential role in formulating learners' perceptions of science and science education. Kelly's (1985) pioneering comments that science has developed a male image because of its construction in a male-dominated society as a male pursuit through the prevalence of males in science careers and in the study of science; that science has been packaged as a pursuit for boys; that gender roles are played out in science classrooms; and that science has an innately masculine image, sum up the debate and place gender stereotyping at the heart of the argument.

Data from the survey questionnaire reveal learners' perceptions of their parents' reported aspirations for them. Learners' gender stereotyping of careers as revealed by the statistics of their

responses is matched, to some extent, by what careers their parents would want them to follow. According to learners' reports, mothers and fathers clearly favour non-science careers for their girls, with mothers showing a stronger stereotypical bias than fathers. While fathers are eager for their sons to pursue science careers, mothers are reported to want both boys and girls to pursue non-science careers. The findings in this research relate to Van Langen et al.'s (2006, p.90) finding that specifically in the case of girls and science careers, girls' choice of science is influenced by family background and specifically parents' education level. In keeping with the stereotype, and confirmed in research done by Crowley et al. (2001, p.258) and Andre (1999), this study established that fathers want their sons more than their daughters to follow a science career and even fewer boys to follow a non-science career. When a more 'hard core' science career was suggested, fathers' desires for their sons appeared to harden into a more stereotyped mould with a 10% incremental increase per grade as compared to their wishes for their daughters. The finding of this research of the reported gender stereotypical views of parents with regard to science concur with that of Bhanot and Jovanovic (2009, p.55) who make the following comment, based on their research with middle school learners from America:

> "Our results suggest that particular parental behaviors can play an important role in creating a positive climate in which girls' attitude towards science develop."

This research has found that gender profiling of careers occurs in the homes of this learner cohort, with parents reportedly perpetuating the stereotype in their career aspirations for their children and endorsing gender stereotypical ideas as to which careers are more suited for men and women. This gives credence to Pieterse's view (2001) in Bonthuys and Albertyn, (2007, p.27) that "people internalise stereotypical expectations".

Researchers (Miller et al., 2006; Jones et al., 2000; Baker and Leary, 1995; Kahle et al., 1993) have commented, and this research confirms, that interpersonal relationships like those involving parents, provide the social context within which the gendering of science takes place. In this cohort of learners with their specific socio-economic and cultural norms and values, gender stereotypes in science appear to be perpetuated through the transference of norms and values. Through interaction and modeling behaviour, parents adhere to and perpetuate gendered, stereotypical profiles of science and science careers. Their children continue to be raised in homes where perceptions of science and scientists still reflect gender stereotyping. The strength and impact of this parental influence is felt on day one of the child's entering the parents' world when blue blankets are bought for boys and pink blankets for girls and when toy cars are given to boys to play with and dolls are given to girls. This research confirms that, at least according to learners' perceptions of their parents, boys are being raised with the expectation of having to fix things around the house

and girls to be sensitive, caring and nurturing. This sets the tone for engagement with science and especially science careers.

As girls who participated in this research progress through the school grades and approach the physical maturity of being able to bear children, the caring and nurturing urge appears to strengthen with a concomitant shift away from pure physical science to affective science. Statistics from this research indicate that the impact of society's conditioning of girls into the role of caring and nurturing appears to remain prevalent, as is evidenced by their predilection for affective science as opposed to the 'purer' sciences like engineering. This research shows that, for girls at the Grade 9 level, society's messages are taking effect, as this age coincides with a puberty phase of acute physical changes, more so for girls than for boys.

Learners' responses in this research confirm that the media is salient in learners' perceptions of science and science education. The persistent, disproportionate imaging of scientists as white-coated males in the print media, referred to by Finson (2004), and the portrayal of scientists on local television and in films as mostly males are recognised by young people. Similar learner expectations about the image of science and scientists in the media as revealed in the analysis of the statistics of the survey questionnaire are also expressed in the comments emanating from the in-depth interviews. In answer to the research question regarding learners' perceptions of the gender of scientists, comments by a boy learner in the in-depth interview bear out the continuation of the trend of the male image of science and scientists. On the other hand, according to the girls, there appears to be progress and a change in that perception as indicated by the extracts that follow: "the scientist character is usually male [be]cause that is what people are used to seeing" and "First it was men[but] ...women are getting more involved ...more empowered". The comments by the girl learners appears to be more in tune with the finding in the survey questionnaire, where boys and girls indicated that they would expect to see men *and* women play the role of a scientist rather than a man or woman exclusively. However, despite this, this study indicates that, faced with a choice of gender, a greater percentage of both boy and girl learners still opted for a male's portraying the role of a scientist in the popular media.

With regard to race and gender in science, even though South Africa is in a post-Apartheid period, the effects of racial separation and the implementation of job discrimination based on colour are still being felt in communities and in the workplace. The responses of learners in this research reveal that they are taking the effects of Apartheid policies on science careers in the past into account. There is a distinction between learners' current expectations, with regard to reported observations of race and gender, and what they think their parents experienced as a consequence of racial separation in the workplace. This indicates that the situation regarding equitable racial

representation in science careers in South Africa is improving. The research question guiding this research is confirmed in that learners do think about race and science careers, but more as an issue that 'belongs' to their parents' generation. This cohort of learners' opinions about racial stereotyping in science careers appears not to change as they progress and move from primary to high school in the GET Phase of education. When these learners were called upon to select categories of opinions regarding gender and science which were based on race and gender, the gender bias and stereotyping of science careers persisted in their responses.

8.2.3 School and classroom experiences of science

Science education, particularly at the GET level, is where the gap in girls' perceptions of and interest and activity in science starts to open up. Schools need to respond to the challenge of encouraging girls to engage more in science at school level so that the numbers entering the science pipeline increase and there is an improvement in the number of women participating in science careers. Stanworth (1981, p.18) argues that:

> "Schools cannot replicate the sexist nature of the world outside and still expect to be taken seriously when, in a careers talk, they say to girls, 'The world is your oyster.' "

This research shows that the signs of a decline in girl learners' science interest and activity and their confidence in science classrooms is visible in the GET Phase of education. These findings confirm those of previous work done by Noonan and Riis (1983), Clair (1995), Miller et al. (2006) and George (2006). This research also noticed the keen interest in science displayed by Grade 7 learners in the primary school weaken by the end of Grade 9 in the secondary school. This finding correlates with that of George (2006, p.571) who undertook a cross-domain analysis of change in students' attitudes about the utility of science and commented that:

> "...attitudes towards science decline over the middle school and high school years."

The enthusiasm for science in the primary school years is well documented in the work done by Omerod and Duckwerth (1975), Kahle and Lakes (1983), Kelly (1985), Adamson et al. (1998) and Andre (1999). The downturn in enthusiasm for science from primary to secondary school is significant for secondary school science since, at the end of this GET Phase, learners select subjects to be pursued in the FET Phase. This situation points towards special efforts that need to be taken to counter the slide in pursuing science. The clear indication in this research of Grade 9 learners' reluctance to do science in the FET Phase confirms the pattern of previous research. The GET science classroom is the crucial site where learners' performance in science, the science teacher's pedagogy, the science curriculum with its activities and the information imparted to learners about science

careers come together to create the environment for learners to want to continue with science in the FET Phase.

The quantitative data of this research reveal that, on the whole, learners are enjoying science across grades and gender, although the boys are having a slightly more positive experience than girls in science classrooms and there is an erosion of this enjoyment level across grades. Learners entering the GET Phase are enjoying science more than those who are in the last year of the phase, which indicates that, as learners are maturing in age and experience, they are becoming less enamoured with science.

This research shows that, in responses regarding their performance levels in science classrooms, learners feel positive towards their performance in science. Across grades and for both genders, whereas a large percentage of GET science learners feel that they are performing well in science, a slightly smaller percentage consider themselves 'good science learners.' Despite the positive feelings towards science, learners across grades and gender are of the opinion that science is not one of their strong subjects, which indicate that they are finding the subject challenging. In eliciting a response from the learners regarding performance in science, the theoretical content of the subject was not separated from the practical aspects and their response was thus to the whole subject. This research reveals a decline in the numbers of girl and boy learners who consider themselves good science learners from Grade 7 to Grade 9. GET learners' performance in science in the primary school is still strong but weakens as they enter the secondary school, where they complete the GET Phase.

The erosion of confidence in their ability in science in the GET Phase is coupled with a decline in GET science performance. This is also linked to the levels of anxiety that learners experience in science classrooms. Whilst the pattern of girls' and boys' responses to categories of opinion regarding anxiety in science classrooms is similar, there are differences. It is evident that, in varying degrees, learner anxiety levels, across gender, are increasing from Grades 7 to 9. Girls in Grade 9 get more worried about science tests than those in Grade 7 and slightly more Grade 9 girls are experiencing feelings of being 'lost' in science classes. A small drop in their confidence levels towards science supports this growing anxiety on the part of Grade 9 girls. In this regard the findings of this research are similar to those of Reid and Skryabina (2003, p.517) who found that:

> "...girls' feelings about their ability to cope with the science course were significantly lower than boys', and significantly fewer girls considered science as 'definitely *my* subject,..."

In boys this lack of confidence is more pronounced in Grade 9 than in Grade 7. The findings from the analysis of the data gained from the survey questionnaire relating to science education indicate that boy and girl learners perceive science education as challenging. This finding is evidenced by their

emotional apprehension in science classes generally and specifically in their performance anxiety in formal evaluation in the discipline.

An analysis of boys' opinions of girls' performance in science exposed an opposite but equal reaction from girls and boys. Whereas girls are of the opinion that they perform better than the boys in science, the boys express exactly the opposite opinion. There is thus some indication that boys are sticking to the stereotype of their being 'better' at science whereas the girls are moving away from the stereotype by asserting their perceived better performance. Scantlebury et al. (2006, p.435), in their research with Japanese students investigating how cultural barriers and the patriarchal structure of Japanese society affected the participation of females in science, similarly found that:

> "Females appear ready to challenge the traditional gender schemas while males appear to avoid the issue altogether."

The research question as to whether learner reported perceptions of performance levels in science assessment are differentiated by gender is thus confirmed.

The aspects in the quantitative study relating to the extent of learners' extra-curricular engagement with science via electronic and print media revealed a paucity that is cause for concern. This research revealed that learner involvement in science activities outside of school hours subscribes to gender stereotypical viewpoints about which science activities would suit which gender: science-related activities that revolved around 'fixing things' were ascribed to boys, and the caring and nurturing activities were ascribed to girls. High learner interest in science and science activity around the home is not translating into intellectual engagement in the form of the pursuit of scientific information. Less than a third of the learners have access to the Internet at home and where they do have access, they are not accessing science information. Learners use computers more for playing games than for academic pursuits. Learners are also not accessing science information in the print media. Less than a third of the learners read books about science or read science articles in magazines or newspapers. Compared to the print media, there is a large positive difference in the number of learners who watch science programmes on television, which is understandable, since television is a more popular medium than print. Consequently, it is not surprising, as is evidenced by statistics that learners do not engage in discussion with friends about science. In addition, learners' participation in co-curricular science activities related to the science curriculum revealed a low enthusiasm. They were not very enthusiastic about joining a science club or participating in science competitions but showed eagerness to go on science outings. It would appear that learners are more eager to partake in what science has to offer, in its application, than in actually 'doing' science.

The use of science learning and teaching support materials, particularly science textbooks can influence learner perceptions of science. Where these materials are not gender-sensitive and affirm

gender stereotyping, learners are continuously sent the message that science is a male domain. A number of researchers (Elgar, 2004; Alexanderson, Wingren and Rosdahl, 1998; Potter and Rosser, 1992; Bazler and Simonis, 1991) confirm the gender bias, in favour of males, in science textbooks.

With regard to science teachers' performance, this research found that learners favour their own gender as the better science teacher, confirming the research question about whether learners' perceptions of science teachers are differentiated by gender. Regardless of the gender of the teacher, girl learners in this research do not feel that boys are being favoured in science classrooms by teachers' calling on boys first to respond to questions or to perform experiments. The boys display markedly less agreement with these opinions. While the girls in this research display a stronger resistance to gender stereotyping by science teachers than boys, the literature indicates that teachers are adhering to and perpetuating the stereotype that portrays science as a male domain, with boys sought out for 'fixing things' in science classes. Similar findings were reported by Rennie (1998) in her research into the social and cultural stereotypical views that educators bring into science classrooms. It is apparent from learners' responses that as practitioners, science teachers bring their own perceptions of gender into science classrooms and that this, together with their pedagogic style, impacts learner' perceptions of science and science education. One can expect that teachers have been raised in the same society that the learners have and therefore science teachers would have similar gender stereotypical perceptions of science and scientists. This was substantiated by learner responses that confirm gendered actions by science teachers.

This thesis confirms Sadker and Sadker's (1994) contention that education continues to reproduce gender stereotypes and to promote the interests of boys to the detriment of girls and that, except for improvements in performance and access to primary and secondary education, few attitudinal and changes of perception towards girls in science education have taken place.

8.3 Recommendations for policy and practice

The phenomenon of the gender stereotyping in science is pervasive, and is intertwined with socio-cultural norms and values that exist and take on different forms in so-called First World and Developing countries. There are implications for developing policies to change gender stereotyping practices to bring about change, because gender stereotyping exists not only in formal social institutions like schools and governance structures (where it can be managed more directly through policies and official guidelines) but also in the norms and values inherent in socio-cultural settings where the challenges of effecting change are more formidable. This begs the question as to where to effect interventions such that they counter gender stereotyping in science and science education in as broad a sphere as possible.

8.3.1 Social contexts impacting on learners

This research has highlighted the impact that the social context of learners' lives has on the gendering of science. Various social inequities all conspire to reproduce practices that maintain the masculine image of science and encourage boys ahead of girls to be interested and engaged in science and science careers: those inherent in learners' and their parents' lack of access to the resources that would counter the effects of gender stereotyping in science; the shortcomings in parenting skills and education levels of parents that could respond to its effects; and the gender stereotyping that is characteristic of the norms and values in the socio-cultural practices of communities.

Whilst South African government institutions like the Gender Commission and gender equity policies act as a watchdog to regulate gender discriminatory practices, social agents like the media and cultural organisations have an oversight role to play. In addition, the latter should themselves practise and promote gender equity practices. The media should be engaged by education and industry to promote careers in science, especially for girls, more than they are currently doing and in ways that engage young people. Media institutions should become more aware of and implement policies and practices that promote gender equity. The relationship between media and government should be strengthened for the promotion and implementation of gender equity policies such that there is a concerted effort to promote women in science and to break down gender stereotyping in this field. Whilst it is challenging to regulate the socio-cultural practices in communities where laws are not infringed, there need to be programmes to support and campaigns to alert communities to the effects of gender discrimination, including its outcome in science.

One such South African government programme that deals with the gender imbalance in science at school level is the national Dinaledi Project that focuses on mathematics and science education. The aim of the project is to increase the rates of participation and performance of girls in science. The Western Cape Province, in which this research took place, participates in this special science education intervention. One of the reasons for the project's inability to make a significant and sustained difference in learner performance in science is its lack of control over the social and cultural influences on attitudes to, perceptions of and beliefs about science which learners experience in their homes and in their interaction with peers outside of the home. Whilst the project is focused on in-school interventions and teacher support, how fathers, mothers, siblings and other family members see the role of girls in science and how gendered their role expectations and stereotyping are, needs to be explored further. The message of the Dinaledi Project needs to be infused into science curriculum policies and implementation strategies more urgently and its

outcomes monitored more closely. Another reason for the slow success rate of the Dinaledi Project is the fact that it is targeted at Grades 10 to 12 learners in the FET Phase. There are no similar specific, targeted, science interventions in the GET or primary school phases. The focus of the Dinaledi Project should also thus include at least the GET Phase of education, since this phase has been identified, in this research also, as the one in which important shifts in learners' science perceptions, attitudes and beliefs are taking place. Reid and Skryabina (2003, p.533) in their study on gender and physics with 10-year-old to 18-year-old Scottish learners, confirm this important period in their comment that:

> "This study also reveals the critical importance for girls of the years of decision where there seems to be a tendency to revert to social stereotypes."

As an intervention measure, the Dinaledi project should focus on countering these shifts, aside from its initiatives in the FET Phase. The participation rates of Grade 10 learners at the site where the Grades 8 and 9 surveys were conducted show a clear decline over a five-year period in the number of girls compared to boys who select physical science in the FET Phase of education (see Figures 4.2 and 4.3 in Chapter Four).

The South African government's formalising of the goal of gender transformation in the form of the Gender Commission, policies for promoting women's participation in the science, engineering and technology sectors, and policies for women's empowerment and gender equity, have elevated the issue of gender equity into the mainstream of politics. The South African government is countering the effects of Apartheid's racial segregation laws that have meant that Black women have been particularly disadvantaged in the science field. Promoting women in science has become a social justice issue, with government's gender laws and equity policies prescribing to the workplace about women's employment. Government policies have been formulated for promoting the participation in and benefit of women from the science sector in South Africa, in an attempt to regain the losses resulting from Apartheid and to maintain participation levels in future. Government institutions, policies and actions that promote gender equity, and specifically the Women in SET (Science Engineering and Technology) policies should be supported and expanded to ensure implementation in institutions and agencies. In this regard, institutions like the Gender Commission and gender equity policies should be given a more prominent voice. The institution of actions like Women's Day and the 'Bring a Girl Child to Work Day', which promote gender equity and highlight gender stereotyping and its effects, should be encouraged and supported more vigorously.

Formal social institutions like schools, however, are the prime sites where programmes can be put in place to promote the greater participation of girls in science, as well as policies and practices to counteract gender discriminatory practices that have as their outcome the gendering of science.

8.3.2 School and classroom experiences of science

Managing the contextual and social issues that impact our understanding of and teaching and learning of science is the key to our countering the effects of the gendering of science in schools and science classrooms. Brotman and Moore's (2008, p.996) concluding comment in their review of science education literature regarding girls and science, that:

> "...we need a wider lens that examines questions of gender on all levels including the school and policy levels. If we are to increase girls' and boys' engagement in science, we need to work toward impacting the education that students receive both inside and outside of the science classroom."

foregrounds the combined and integrated efforts that need to be undertaken at all levels in society to deal with the issue of the gendering of science at school and science classroom levels. The inability of schools to effect policies and practices to deal with the issue of gender stereotyping and to influence the school and classroom science experiences of boy and girl learners needs to be addressed if we are to respond to the gender-skewed perceptions of science and science education of our South African learners: one needs to examine the curriculum for aspects where science teachers address issues like equity and access; the nature and the masculine image of science; the development of learners' science identities; and the manner in which science is taught.

The current national mathematics and science improvement strategy aims to increase the number of science teachers and improve the qualifications of those currently in the education system, but a special effort needs to be made to conscientise current and prospective teachers about gender stereotyping and its adverse effects. Teachers need, in the first place, to be made aware of their own gender stereotypical perceptions and attitudes, which they bring into science classrooms. Awareness programs, gender sensitivity training and gender equity advocacy programs would lay the groundwork for increased knowledge and understanding of the issues involved. Then they need to be equipped in how to change these, so that their teaching practice reflects an unbiased view. The way in which science teachers teach the science syllabus should receive special attention to root out any gender bias in its implementation. In this regard, Carlone's (2004) call, for a more gender-fair science education that accounts for girls' biological, cognitive and social differences and results in more equitable classroom treatment for girls, finds resonance in this research.

Current strategies to increase the number of girls pursuing science studies at FET and tertiary levels of the education system, like the Dinaledi Project and MST (Mathematics, Science and Technology) strategies, need to be more effectively supported, and expanded to include all schools

instead of just those in the strategy. Considering that the decline in enthusiasm and performance in science becomes prominent in the latter part of the GET Phase, clearly there is a need to intervene in science classrooms in the GET Phase: the primary school as a whole should be targeted for science education interventions.

Naidoo and Savage's (1994) argument that issues of curriculum content and delivery are as important as policy formulation and the equitable distribution of science resources for promoting equity, is significant, and also has meaning in this research. The science curriculum needs to be made more girl-friendly and actively reflect and foreground gender issues. In preparing and delivering science lessons teachers could for example make a point of referring to the gendered nature of science and challenge perceptions of its masculine image. This practice should be even more focused in the practical work that accompanies theoretical lessons in science since it is the practice of science, as this thesis' demonstrates, that perceptions persist that science is a male pursuit.

Gender stereotypes need to be overtly challenged in the ideology of the science curriculum and teachers should be encouraged to confront gender stereotyping in their practical implementation of the science curriculum. The comment by Hughes (2001) that it is necessary to make modifications to the science curriculum, to make it more accessible to and inclusive of girls, so that it extends beyong its limits of masculinity, race, class and ethnicity, is relevant for the current South African national science curriculum. The observation of the Office of the Status for Women (2000, p.12) of the South African government that, despite innovative improvements, gender stereotyping and women's subordination continues to present challenges for curriculum development, still holds true for the science curriculum today.

Teachers need more pertinently to take cognisance of the influence they have on learners' perceptions. The effect of their interaction style in science classrooms on learners strengthens gender stereotyping of science and endorses the messages that learners are getting from society and the media. They need to realise that their perceptions of, attitudes to and expectations of girls and boys in science classrooms may be gendered, and that this could impact on their classroom interaction. What is needed is more girl-friendly science lessons (Head and Ramsden, 1990) in order to broaden the appeal of science to girls.

There is already fertile ground for building on positive feelings in science classrooms since, as mentioned earlier, despite some anxiety about performance in science evaluation, learners feel positive about science. In addition girls, who do not perceive gender bias in classrooms as much as boys do, appear to have views that are less stereotyped than that of boys. Programs in schools about gender equity should take cognizance of this and need to target boy learners who appear to be

sticking to the stereotypical perceptions of gender. The indications emerging from the qualitative in-depth interviews that girls are regarded as the leaders in class would point towards possibilities for promoting such girls to spearhead programs aimed at raising awareness about gender issues and achieving gender equity. Care should however be exercised not to alienate boys but rather to include them in the programs and activities while using girls' active engagement and leadership.

Teachers have little control over socio-cultural influences outside of the science classroom that affect learners' perceptions of science and scientists. In this regard, De Vos (1998, p.297) labels this arena where there is a lack of control over the social and cultural influences that affect attitudes to, beliefs about and perceptions of science as "closed worlds". This research examined aspects of these "closed worlds". It is clear that the impact of socialisation and culture on attitudes to, beliefs about and perceptions of science is strengthened by educators' own attitudes to, beliefs about and perceptions of science; they bring these to the classroom and they proliferate through classroom interaction in the delivery of science lessons. The way that teachers teach science is thus also an important factor. They have to persuade girls to become more enthusiastic in the pure sciences, such as chemistry and engineering, in addition to affective sciences like biology. Teachers should get more learners, especially girls, to do science in class in a more practical way. They should encourage them to ask questions and become inquisitive about science, instead of just doing theoretical presentations and letting learners hand in written assignments and projects. Teachers should recognise gender differences in science classrooms and adapt their teaching styles to suit these differences. Fadigan and Hammrich (2004, p.856) confirm this view, together with Arnot (2000), who argues that classroom instruction should become more personalised and reflexive for girls.

Science teaching should be made more girl-friendly: teachers should be more aware of the need to make their teaching style free from gender inequalities and the science curriculum should be delivered free from gender bias. Blickenstaff (2005, p.376) expresses the same view:

> "Some of the reasons girls express discomfort with science can be addressed by altering curriculum materials and pedagogy..."

The science curriculum content, then, should be sensitive to the life worlds of girls. In the literature there are calls to make science more inclusive and to teach science in a manner that is girl friendly by connecting with the social and cultural worlds of especially girls (Brickhouse et al., 2000; Tobin et al., 2001; Parsons et al., 2008; Andersson et al., 2009; Nystrom, 2009).

This research confirms that the social and educational potential of parents to foster science interest and activities in their children is limited by their personal economic potential. Sui Chu Ho (2010), in her study examining family influences on adolescents' science learning, confirms this and bears out the findings of this research that a family's financial status has an effect on parents' ability

to fund the science interests and activities of their children, so vital in fostering further involvement in science. She comments that:

> "However, out-of-school opportunities would have financial and other resource implications; hence students from disadvantaged families need support …in order to engage these learning opportunities at an early stage of schooling." (Sui Chu Ho, 2010, p.426)

Schools need special financial support to sustain the teaching of science and promote it as a subject. The schools in this research can be categorised as being located in a lower class, poor socio-economic area: the parents who contribute to the school's functioning have limited financial resources to impact the interest in, activities and perceptions of science via focused actions. These schools face the challenges of human and physical resourcing and the finances to facilitate these. Parents are not always able to finance trips to places of interest in the science field that would encourage learners. Schools located in these communities don't have the necessary financial resources to fund these outings. In addition, schools located in lower class, lower income communities do not always attract the best teachers and in many cases do not have adequately qualified teachers in crucial subjects like science. This leads to poor academic results, but more than this, it results in a dearth of teacher inspiration to learners, especially girls, to take an interest in and perform well in science. One would not expect science learners in these schools to participate optimally in science Olympiads or science clubs. Science and science education have thus also become class issues and therefore social justice issues. Freeman's (2004) view that socialisation experiences, mediated by the social class in which learners are located, are partly responsible for disparities between girls and boys with regard to perceptions of science, rates of participation in science activities and pursuing science careers, is confirmed by this research.

8.3.3 Learners' perceptions of and interest in science

The ongoing challenge to impact learners' perceptions of and interest in science through improving learner participation in intellectual activities like reading and engaging in science, needs to find expression in teaching strategies and education policies in order to improve science awareness, especially amongst girls.

Learner access to the Internet and specifically science-related websites needs to be encouraged and supported financially in the formal education sector. Including such science activities via formal teaching strategies is important if we are to use the Internet (increasingly popular with young people) to convey the message of involvement in science, especially that of girls, as being imperative for South Africa's development in the field of science.

Learners' vocational literacy should be improved, and their knowledge and experience of careers promoted, via popular media channels, including cellular phones, especially in lower and middle class public schools. This would broaden their level of understanding of careers especially in the science field. In this respect, Life Orientation teachers should be encouraged to be more explicit and 'drive' the issue of what careers entail across a wider spectrum. The Intermediate and Senior Phases of the primary school should be targeted for special attention to help prepare for subject choices, especially for girls in science, in the secondary school FET Phase. Learner visits to places of interest relating to science should be promoted more urgently and learners in schools across social strata, especially the lower middle class and sub-economic area schools, should be targeted for this intervention on an ongoing, as opposed to a once-off, basis.

The above recommendations will add to strategies to increase the number of learners, especially girls, opting for tertiary study in the 'pure' sciences. The generally held perception that science is a 'difficult' subject, that it requires higher cognitive ability and alienates girls in particular is somewhat challenged by the findings in this research, since learners are enjoying science across grades and gender and feel positive towards their performance in science, even though it drops off with age. This positive sentiment is perhaps not sufficiently exploited in the secondary and tertiary education sector. Research should be conducted as to the reasons for the positive association with science and its findings utilized to build and sustain these teachings and experiences to the final grades as well. Existing strategies at tertiary education institutions, like gender studies departments, should be supported more adequately and especially these should similarly be researched and efforts made to infuse a more positive sentiment.

8.4 Limitations of the study and recommendations for further research

One of the emerging findings in the study, especially apparent from the in-depth interviews, is that learners do not have a clear understanding of the terms 'science', 'scientists' and 'science careers'. Pivotal to this understanding is the manner in which they experience these concepts in their everyday lives and in school science classrooms, and how these are communicated to them in society through the media and interpersonal interaction in the socialisation process. The concept of science that is communicated to learners through the formal academic curriculum in schools is exclusively that of 'pure' science. This traditional concept of science and the manner in which science has been practised is at the heart of criticism of science by feminists, that, by definition it excludes those aspects that would bring more women 'into its fold'. Harding (1986, p.289) points this out when stating that:

> "It is clear that feminist criticisms of the natural and social sciences have identified and described science badly practiced – that is, science distorted by masculine bias in problematics, theories, concepts, methods of inquiry, observations, and interpretations of results of research."

One of the challenges in the learners' response to the questionnaire is the fact that they lack knowledge and understanding of careers. In many cases they have not encountered nor engaged with someone in a particular career and thus have hearsay knowledge only about that career – their lived, social reality has limitations. Learners' responses were thus also influenced by this reality. Not enough women are seen by young people to participate in science, science education and applied science careers. The image of women participating in certain science careers has not been sufficiently constructed in their social spheres for them to accept this image into their frames of reference when expressing their perceptions about science and science education. The findings of this research confirm Fensham's (2004) reference to the under-representation of women as role models in science careers, which states that science education is servicing two sexes and hence there is a gender issue in science education. The influence of society and culture on learners thus affects their perceptions of science and science education. The question that can be repeated for different science careers is, "How many women mechanical engineers have learners been exposed to?" This occurrence needs to be considered when interpretations are made about learners' responses to survey questionnaires about gender and careers.

In focusing on science identity development, the question that emerges with regard to this cohort of learners is whether they have developed a science identity or at what point they are in the development of their science identity. This can be identified as a limitation since learners' progress in the academic phases is not an indication of how far their science identity has developed. This limitation has also been referred to by Tucker-Raymond (2007, p.590):

> "...we cannot generalize from our findings about actual and designated identities that young children have and develop in school when engaged in science in a particular way."

Further research needs to be undertaken about learners' understanding of the concepts of science and scientists, and the manner in which these terms are used and explained to learners by science teachers, since it became apparent in this research that they did not fully understand these terms. The factors that influence and affect learners' occupational interest should be investigated in order to establish what it is that steers especially girls away from 'hard core' science careers like engineering and towards the affective sciences.

Emerging from this study Brotman and Moore (2008, p.993) propose questions for further research under the themes of equity and access; curriculum and pedagogy; the nature and culture of

science and identity. Many of these find resonance in the educational contexts of the learner cohort that participated in this research and emerge clearly out of this research project as well.

With respect to the educational context of the learners in this research are: the need to implement and evaluate interventions at the primary school level and extra-curricular science experiences; curriculum and in particular gender inclusive pedagogy; teacher education and development programmes; gender-inclusive curricula; and further exploration of the nature and culture of science and science identities.

Archer et al. (2007, p.566) agree with Brotman and Moore's above-mentioned comment on the need to further investigate social inequities and imbalances of girls' science experience:

> "In this respect, we would argue that policy, research and practice should start to make urgent steps to redress this imbalance and to recognize the impact of multiple social inequalities within such young women's lives."

The sample used in this research was drawn from a largely homogenous community with learners having the same racial, class, ethnic, socio-cultural and economic backgrounds, partly because the community was placed in this geographical area as a consequence of the Apartheid policy's practice of separating communities. This created a limitation in that learners from other racial, ethnic and economic backgrounds were excluded from the study because of their geographic location, with the subsequent logistical challenges that this presented. Therefore, whilst this research was done in lower middle class schools, research should be done in upper middle class and sub-economic schools (in other words, with a wider diversity of learners) to establish the validity of these findings and to ascertain whether gender and science perceptions have become a class issue.

One of the aspects of the findings of this research that leads me to make the previous comment is that this research identified the limited access to computers, and specifically the Internet, that learners have. This limits their ability to access science and science career information. Schools attended by this cohort of learners are limited financially to funds that they receive from government, coupled with the amount that parents can afford to pay in school fees – being in areas where the unemployment rate is high, this is low. This means that the schools are unable to finance access to the Internet, thereby limiting learner access. The implication is that the relative influence of the 'closed worlds' of socialisation and culture on learners' attitudes, beliefs and perceptions of science needs to be examined more thoroughly in research.

8.5 Conclusions

There is awareness of the gender disparities that exist in our society, both in the formal aspects of our lives (comprising our engagement with various institutions) and in the informal social

interactions that takes place in our everyday lives. There is a realisation of the need to correct the imbalances and various institutions and agencies are endeavouring to bring about an equitable balance. The fact that gender stereotyping and the imbalances that it creates have been recognised as a social justice issue by their inclusion in a legal framework and government equity policies has meant that it is being confronted in a formal manner in society. The influences of socialisation and culture are more insidious and require constant vigilance, confrontation and action to diminish their effect.

There can be no one site where interventions can be targeted to apprehend the effects of gender stereotyping or one entity to manage such a process and a co-ordinated, co-operative effort is required. Formal institutions, whether in government or in socio-cultural settings, have a particular role to play in raising awareness of gender stereotyping and its effects in science and science education. Government funded national media awareness programs, formal government intervention programs, government socio-cultural institutions like social welfare departments and schools especially primary schools and hospitals, should run gender sensitivity and gender equity advocacy programs that raise awareness. Religious institutions where rituals reflecting gender stereotyping is endemic are sites where gender stereotyping is not challenged as vigorously as it should and whilst there is a recognition that influencing such practices is an onerous task, a way should be found to influence thinking and actions in the domain of gender and the effects of stereotyping.

We need to constantly and consistently work at the occurrence of gender imbalances in society and the injustices that flow from them. Girls especially will, as women do today, face the dichotomy of maintaining socio-cultural values whilst continuing the battle for women's rights and empowerment in especially the economic field. It would appear that the socio-cultural world in which women find themselves is being challenged to align itself with the advances that have been in the economic world of careers and professional development made as regards the role of women. The 'gender and perceptions of science' issue is central to this struggle and plays itself out in this environment.

Indications from this research, and research elsewhere, are that girls are resisting gender stereotyping and that the rhetoric of women's empowerment appears to be impacting girls' views on science, science education and science careers. Some parents appear to be 'powering' up their girls to break down stereotypes, to break down emotional dependency and to become more independent. Many parents, however, appear to be 'protecting' the male dominance of boys by raising them to accept that they have to be physically strong men, thereby supporting and enhancing stereotypical gender profiles, especially in careers in the 'hard core' sciences.

Archer and Yamashita's (2003, p.130) summary up of what needs to be done finds resonance in the South African context:

> "…policies need to move away from deficit models in which social and educational problems are located within working-class and minority ethnic cultures and families and where the problems of inner-city boys are understood in terms of their 'deviant' masculinities. Instead, we argue for further sensitive analyses to be undertaken of the complex racialised and classed aspects of urban (and other) masculinities in order to inform theories, policies and practices that can work towards challenging, rather than reproducing, multiple inequalities." (Archer and Yamashita, 2003, p.130)

The need for constant and consistent pressure for change is imperative if we are to counter the effects of gender stereotyping in society and in formal institutions. Policies for women's empowerment and gender equity need to be implemented more stringently if the inordinate and disproportionate abuse of women, a direct outflow of the gender bias against women, is to be challenged. There is a need to highlight more pertinently the role of women in science and the involvement of women in science should be brought more robustly to the fore, so that it becomes more visible in the social reality and the lived experience of girls.

The socio-economic strata and the social class in which the learners' families are located are factors in their perceptions of science and science education. Jayaweera's (1997) observation remains relevant in this study that, despite advances in education, socio-economic constraints that perpetuate poverty and social class differentiation reinforce gender stereotyping.

The disparities in science participation between girls and boys, has seen the politicisation of the ideology of science as a masculine domain. Kleinman's (1998) and Howes' (2000, p.396) recognition of the growth of this political view of girls' participation in science is thus confirmed. The prominence of the South African government's actions such as the Policy for Women's Participation in and Benefit from the Science, Engineering and Technology (SET) sector, besides gender equity policies, bears testimony to the recognition of the need for girls' increased participation in science, in this struggle. Bendix's (200, p.435) comment in this regard is apt:

> "Women, too, have become more vociferous in their demands and are particularly sensitive to discriminatory practices."

Continued gendered, stereotypical images of science via formal publications, in films and to promote the sale of products mean that South African society continues to construct a male-dominated picture of scientists and science. Whilst a change in learner perceptions is noted, particularly regarding films and television, not enough is being done to improve the situation. Because of the popularity of film and television with young people, the packaging of science and

scientists and the images of heroines and heroes in science fiction movies become an important factor to influence the hearts and minds of impressionable young people regarding science.

It is apparent from this research that in the home, as well as in schools, learners' interest in science is not translating into a significant level of science activities of an academic nature (like reading science articles or stories, talking about science, entering science Olympiads or belonging to science clubs). This gap is breaking the continuity of learners' positive science perceptions and interest during especially the primary school years of the GET and their choosing science as a subject in the FET Phase, continuing with tertiary studies in science and ultimately pursuing a career in science.

From responses by the learners in this research, it appears that parents, perhaps preoccupied with the challenges of raising children, are abrogating their responsibility to nurture their children's interests in science and leaving the task to science teachers. Ndunda and Munby's (1991) reference to socialisation and the home as key contexts responsible for the disenfranchisement of girls as science participants, and the socio-cultural context of science learning referred to by Kahle and Meese (1994), Kreinberg and Lewis (1996) and Clair (1995), point to the potential for parents of the learners in this research to influence the family variables that shape the self-image of female science learners.

There is a lack of continuity between home and school with regard to formal science learning in schools and science activities at home. Osborne and Collins (2001, pp.461-462) refer to this lack of continuity as "the mismatch between science in society and science in school". This feeds into the current state of affairs in science, where, as evidenced by this research, stereotypical images that promote science as a male domain are leading girls to believe that they don't have the necessary academic skills or physical strength for science and that science is thus not for them. The propagation of the male dominance of science is embedded in young people's thinking and confirms Evans's (1996) observation that societal processes conspire to reproduce the status quo.

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REFERENCE LIST OF ANNEXURES

A.Learner quantitative survey questionnaire

RESEARCH PROJECT: SCIENCE EDUCATION

1. DEMOGRAPHICS: INFORMATION ABOUT YOU AND YOUR FAMILY

1 Are you a boy or a girl? **Make a tick in the block**

Girl	1	Boy	2

2 What grade are you in

7	8	9

Make a tick in the ONE block that describes you the best

3 What language(s) do you speak at home

English only	Afrikaans only	Xhosa only	English and Afrikaans	Xhosa and English	Xhosa and Afrikaans	Other: specify
1	2	3	4	5	6	7

4 Of what religious group are you a member?

Moslem	1
Catholic	2
Anglican	3
Baptist	4
Seventh Day Adventist	5
Moravian	6
Apostolic	7
Dutch Reformed Church	8
Other: Specify	9

5 How old are you? **Make a tick in the block**

12 years	13 years	14 years	15 years	16 years	older than 16 years
1	2	3	4	5	6

6 In which month were you born? **Make a tick in the block**

January	1	July	7
February	2	August	8
March	3	September	9
April	4	October	10
May	5	November	11
June	6	December	12

Are your parents still alive? **Make a tick in the block**

7	Mother	yes	1
		no	2
8	Father	yes	1
		no	2

9 Who do you live with **MOST of the time**?

Make a tick in the ONE block that describes your situation the best.

MOTHER & FATHER	FATHER ONLY	MOTHER ONLY	UNCLE AND/OR AUNT	GRANDMA AND / OR GRANDPA	FOSTER PARENT	OTHER: SPECIFY
1	2	3	4	5	6	7

10 If your father is still alive, is he employed? yes 1 no 2

11 If your mother is still alive, is she employed? yes 1 no 2

12 If your father is still alive and he works, what kind of work does he do? **Write down the job/career**

.....

13 If your mother is still alive and she works, what kind of work does she do? **Write down the job/career**

.....

14 What is the highest grade/standard that your mother passed?

Make a tick in ONE block only

I don't know	1
lower than grade 8	2
grade 8 or grade 9	3
grade 10, 11 or 12	4
Tecknikon/College	5
University	6

15 What is the highest grade/standard that your father passed?

Make a tick in ONE block only

I don't know	1
lower than grade 8	2
grade 8 or grade 9	3
grade 10, 11 or 12	4
Tecknikon/College	5
University	6

2. INFORMATION ABOUT WHAT INTERESTS YOU

What are the things that interest you?

Make a tick in the block that shows your level of interest:

	1= very little,	2= a little,	3= a lot,	4= quite a lot,	5=very much
16	How cars and machines work	1	2	3	4	5
17	How mothers produce baby's milk	1	2	3	4	5
18	How gadgets like DVD players work	1	2	3	4	5
19	How medicines heal illnesses	1	2	3	4	5
20	How Cancer is treated	1	2	3	4	5
21	How computers work	1	2	3	4	5
22	How fat is produced in the body	1	2	3	4	5
23	How sick animals are treated	1	2	3	4	5
24	How volcanoes are formed	1	2	3	4	5
25	The planets in the solar system	1	2	3	4	5

Resources in the home with a science connection: **Do you have the following items in your home?**

MAKE A TICK IN THE BOX

26	a calculator	yes	1	no	2
27	a computer (not video game or TV)	yes	1	no	2
28	a tool box	yes	1	no	2
29	an electric drill	yes	1	no	2
30	a generator for when the lights go out	yes	1	no	2
31	a microwave	yes	1	no	2
32	an electric iron	yes	1	no	2
33	an electric stove	yes	1	no	2
34	a TV	yes	1	no	2
35	a car	yes	1	no	2
36	a DVD player	yes	1	no	2
37	a music centre	yes	1	no	2
38	a vacuum cleaner	yes	1	no	2
39	a washing machine	yes	1	no	2
40	a fridge	yes	1	no	2
41	a home alarm system	yes	1	no	2

42	if you have a computer, is it connected to the internet	yes	1	no	2

If you have a computer at home, what do you do on it MOSTLY?

Make a tick in the block that shows your level of interest:

	1= very little,	2= a little,	3= a lot,	4= quite a lot,	5=very much
43	play computer games	1	2	3	4	5
44	do school assignments	1	2	3	4	5
45	e-mail my friends	1	2	3	4	5
46	visit science web sites	1	2	3	4	5
47	visit web sites that tell me more about curing illnesses	1	2	3	4	5
48	visit web sites about how the mechanics of cars work	1	2	3	4	5
49	visit web sites about new scientific inventions	1	2	3	4	5

50 What kind of work would you like to do one day?

.....

	Have you ever.....	**Make a tick in the block**			
51	Fixed a broken cell phone	Yes	1	No	2
52	Helped someone get over the flu	Yes	1	No	2
53	Connected the wires of an electric plug	Yes	1	No	2
54	Baked a cake	Yes	1	No	2
55	Fixed an elctrical hair dryer	Yes	1	No	2
56	Grown plants from seeds	Yes	1	No	2
57	Helped to clean up the environment/your neighbourhood	Yes	1	No	2

Circle the response that best describes your view

1 = I really **don't like** it, **2 =** I like it **a little**, **3 =** I **sometimes like** it
4 = I **really like** it **5 =** I like it **very much**

I LIKE.....

58	Reading science articles in newspapers	1	2	3	4	5
59	Reading science articles in magazines	1	2	3	4	5
60	Watching science/nature programs on TV	1	2	3	4	5
61	Having a science related hobby	1	2	3	4	5
62	Reading books about science or scientists	1	2	3	4	5
63	Talking about science to friends	1	2	3	4	5

Circle the response that best describes your opinion

1 = WOULD LIKE IT VERY LITTLE, 2 = WOULDN'T REALLY LIKE TO 3 = WOULD SOMETIMES LIKE TO,
4 = WOULD REALLY LIKE TO 5 = WOULD VERY MUCH LIKE TO

I would like to do the following in the future

64	Enter a Science quiz/competition	1	2	3	4	5
65	Go on a science trip to the aquarium	1	2	3	4	5
66	Visit a hospital to see how HIV and AIDS is treated	1	2	3	4	5
67	Belong to a science club that carries out experiments	1	2	3	4	5

68 What kind of job would your father like you to do when you leave school?
Make a tick in ONE block

Help in healing sick people	1
Teach children how to read and write	2
Sell products to customers	3
Fix electrical gadgets like computers	4
Become a professional sports person	5
Look after sick people	6
Help people solve their problems like getting their pension	7
Fix mechanical or electrical problems on cars	8
Manage a shop	9
Other **(write it down)**.....	10

69 What kind of job would your mother like you to do when you leave school?
Make a tick in ONE block

Help in healing sick people	1
Teach children how to read and write	2
Sell products to customers	3
Fix electrical gadgets like computers	4
Become a professional sports person	5
Look after sick people	6
Help people solve their problems like getting their pension	7
Fix mechanical or electrical problems on cars	8
Manage a shop	9
Other **(write it down)**.....	10

3. INFORMATION ABOUT YOUR SCIENCE/NS IN CLASS

Which statement fits your opinion best? **Circle the number in the block**

		AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
70	I usually do well in NS/ Natural Science	1	2	3	4

		AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
71	NS/Natural Science is more difficult for me than for many of my classmates	1	2	3	4

72 I consider myself a good NS/Natural Science learner.	AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
	1	2	3	4
73 I am usually more worried about NS / Natural Science tests than other tests.	AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
	1	2	3	4
74 The girls in our class usually do better than the boys in NS/Natural Science tests	AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
	1	2	3	4
75 I would like to take Physics in grade 10	AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
	1	2	3	4
76 I would enjoy being a scientist	AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
	1	2	3	4
77 I think learning science will help me in my daily life	AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
	1	2	3	4
78 NS/Natural Science is not one of my strong subjects	AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
	1	2	3	4
79 My science teacher expects me to do well in the science examinations	AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
	1	2	3	4
80 Sometimes my science teacher makes me feel stupid	AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
	1	2	3	4
81 Women NS/science teachers are better than men NS teachers	AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
	1	2	3	4
82 **My** best NS/Natural Science teacher so far was a male	AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
	1	2	3	4
83 Our teacher usually **first** asks a boy a question during NS/Natural Science lessons before asking a girl.	AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
	1	2	3	4
84 Our teacher usually **first** asks a boy to do experiments in the NS/science lesson before asking a girl	AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
	1	2	3	4
85 My science teacher encourages me to learn more science after the NS/Natural Science classes	AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
	1	2	3	4
86 Sometimes when I do not at first understand something in NS/Natural Science class, I know that I will never understand it.	AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
	1	2	3	4

		AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
87	We learn about important things in the NS/Natural Science class	1	2	3	4
88	I enjoy learning NS/Natural Science	1	2	3	4
89	NS/Natural Science is fun	1	2	3	4
90	I have a good feeling towards NS/Natural Science	1	2	3	4
91	My mind goes blank when I am doing NS/Natural Science.	1	2	3	4
92	In NS/Natural Science class I feel 'lost' because I don't understand the concepts.	1	2	3	4
93	I copy NS/Natural Science homework from my friends more than other learning area homework because I don't understand the concepts in NS/Natural Science	1	2	3	4
94	In NS/Natural Science class I walk around and am more disruptive than in other classes because it means I don't have to do the work	1	2	3	4
95	I talk to my friends more during NS/Natural Science lessons than other learning area lessons because I don't like the work in NS/Natural Science lessons	1	2	3	4
96	I copy more in NS tests because I don't understand the work	1	2	3	4
97	I don't like participating in NS/Natural Science lessons because don't understand the the work in science.	1	2	3	4

4. YOUR VIEWS ON SOCIETY, SCIENCE, GENDER AND CAREERS

Make a tick in the blocks below that best describes your views/opinions

98 My best friends are....

Mostly boys	Girls and Boys	Mostly girls
1	2	3

99 Which doctors do you think are better - women or men doctors?

Women doctors	1
Men doctors	2
Women and men are equally good	3

100 Who do you think is better at planting and looking after plants at home

Women are better	1
Men are better	2
Women and men are equally good	3

101 Who do you think is better at looking after the children?

Women are better	1
Men are better	2
Women and men are equally good	3

102 I think scientists are 'cool' people

AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
1	2	3	4

103 Everyone should learn about science

AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
1	2	3	4

104 I will probably not do well in Science in the examinations

AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
1	2	3	4

105 Consumer Studies is a subject that is meant for girls

AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
1	2	3	4

106 It is a boys job to help his father fix machines around the house

AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
1	2	3	4

107 If I was visiting the ESKOM nuclear power station, **I expect** the manager to whom I would be introduced, to be a **MAN**

AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
1	2	3	4

108 Only men should be put in control of driving trains

AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
1	2	3	4

109 Women are better at looking after sick people than men

AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
1	2	3	4

110 Men are better rocket scientists than women

AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
1	2	3	4

111 Girls should help their mothers with sewing jobs in the home

AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
1	2	3	4

112 Girls who are very good in science at school don't get boyfriends as quickly as girls who really don't like science

AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
1	2	3	4

113 I don't like girls who always get very high marks in science

AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
1	2	3	4

114 My friends and I think girls who are very good in science are NOT cool.

AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
1	2	3	4

115 Science is good because scientists invent cool gadgets that I can use

AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
1	2	3	4

116 Science improves the lives of people because scientific inventions have helped farmers to produce more food and therefore less people go hungry

AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
1	2	3	4

117 It is more difficult for girls than for boys to become a scientist like an engineer

AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
1	2	3	4

118 It is more difficult for boys than for girls to become a nurse

AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
1	2	3	4

119 When I visit the hospital I **expect** the doctor to be a white man rather than a Black African man

AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
1	2	3	4

120 When I visit the hospital I **expect** the doctor to be a white man rather than a Coloured man

AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
1	2	3	4

121 When I visit the hospital I **expect** the doctor to be a man rather than a woman

AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
1	2	3	4

122 When I visit the hospital I **expect** the nurse to be a Coloured/Black African woman rather than a Coloured/Black African man

AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
1	2	3	4

123 When my mother and father were young, I think that medical doctors were mostly white men rather than Coloured/Black African men

AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
1	2	3	4

124 When my mother and father were young, I think that medical doctors were mostly white men rather than white women

AGREE A LOT	AGREE A LITTLE	DISAGREE A LITTLE	DISAGREE A LOT
1	2	3	4

5. YOUR VIEWS ON THE MEDIA:
Read the statements and circle the number of your response

125	In TV programs you would **expect** the role of a scientist **mostly** to be played by....	1	Women
		2	Men
		3	Women and men equally
126	In films/movies you would **expect** the role of a scientist mostly to be played by....	1	Women
		2	Men
		3	Women and men equally
127	In most TV programs, **I expect** that the role of looking after sick children is played by....	1	Women
		2	Men
		3	Women and men equally
128	In science fiction (Sci-fi) films **I expect** that science experiments will be done mostly by a....	1	Woman
		2	Man
		3	A woman or a man equally
129	In popular magazines **I expect** that the people who look after the sick are mostly portrayed as.....	1	Women
		2	Men
		3	Women and men equally
130	In films, **I expect** that the "coolest" action heroes who use science to solve problems like getting out of dangerous situations are.....	1	Women
		2	Men
		3	Women and men equally
131	In films, **I expect** the the role of a scientist to be played by a.....	1	white Women
		2	white Man
		3	white Woman and white Man
132	My friends who think that science fiction movies are 'cooler' to watch than romantic drama's are....	1	Girls
		2	Boys
		3	Girls and boys equally
133	My friends who think that movies in which science gadgets are used are 'cooler' to watch than comedies are....	1	Girls
		2	Boys
		3	Girls and boys equally

THANK YOU VERY MUCH FOR YOUR OPINIONS AND HELP!!

B. Qualitative semi-structured, in-depth interview

QUALITATIVE DATA GATHERING:
THE SEMI-STRUCTURED, IN-DEPTH INTERVIEW

To the interviewer:

1. Introduce yourself.
2. Establish whether the interviewee is comfortable.
3. Explain what the interview is about.
4. Ask if the learner is willing to participate in the interview.
5. Complete the demographics questionnaire of the interviewee.
6. Note the date and time of the interview.
7. Explain what will happen and how long the interview is probably going to take.
8. Establish the 'decision-making' profile of the family i.e. who makes the decisions in the family about various aspects of family life e.g. who decides where to go and eat out, who decides about the dress code of children, who has more say over the career choices of children. In establishing this profile the interviewer tries to ascertain the control mechanisms, power relations and possible socio-cultural influence in the family i.e. whether it is matriarch - or patriarch- controlled family.
9. Establish whether there is a 'history' of scientists or science-related careers in the family to ascertain whether the learner is open to past experience in his/her own family social circle.
10. Establish the friendship/peer pattern of the interviewee. Do the learner's close friends consist of both sexes or does the learner tend to have only one sex group that he/she counts as his/her very close friendship group? This is to assist in establishing the realm of influence on the learner – whether he/she is susceptible to peer pressure from one sex group to conform to societal norms.

Questions to guide the qualitative data-gathering:

1. What do you think about girls who want to become car mechanics?
2. Do you think boys/men should do the housework like cleaning and cooking? Why or why not?
3. Who should look after babies – mother or fathers – when a parent goes out to work?
4. What do your male/female friends think about girls wanting to become scientists/doctors?
5. Explain to the interviewee that medical doctors are regarded as scientists and then pose the question: Why do you think there are more men doctors than women doctors?
6. Do you think boys would like to become dress designers? If so – why? If not – why?

7. Most times, when a scientist/engineer is pictured in a magazine/film is 'it' a man or a woman? Why is this so?

8. Who are the leaders in the class i.e. if a class decision needs to be taken whose 'will' usually prevails – the girls or the boys? Is there a lot of argument about this or is the leadership role readily accepted?

9. Why do they think as many girls don't follow science careers (like becoming doctors) as boys?

10. Why do they think more boys take science related careers like becoming automotive/car mechanics?

11. Do they prefer a male or female science educator? Why? Do they think male science educators are better than female science educators?

NB!! THANK THE LEARNER FOR PARTICIPATING IN THE PROJECT/ INTERVIEW

1. What do you think about girls who want to become car mechanics?
   Areas for the categorisation of responses:
   a. girls aren't physically strong enough to turn spanners, lift heavy things etc. : gendered stereotyping of girls as physically weaker than boys
   b. girls don't know how cars work: gendered stereotyping of girls as not equally intelligent/able to understanding scientific 'things' like boys
   c. it is not a job for girls: gendered stereotyping girls into socially accepted career paths

2. Do you think boys/men should do the house work like cleaning and cooking? Why or why not?
   Areas for the categorisation of responses:
   a. It's girls'/women's work or girls/women are supposed to do it. Gendered role expectations
   b. Men don't know about housework/cleaning/cooking: gendered role expectations – the expected knowledge base of men and women are perceived to be different due to socialisation

3. Who should look after babies – mothers or fathers – when a parent goes to work?
   Areas for categorisation of responses:
   a. Gendered stereotyping (due to socialisation and the effects of culture) of the duties of parents
   b. It's a mother's "duty" to look after the children (nurturer) whilst the father (provider) goes out to work.

4. What do your male/female friends think about girls wanting to become scientists/doctors?
   Areas for the categorisation of responses:
   a. Gendered peer (APB) attitudes, perceptions and beliefs about gendered role expectations

5. Why do you think there are more men doctors than women doctors?
   Areas for the categorisation of responses:

a. Gendered role expectations
b. Gendered stereotyping

6. Do you think boys would like to become dress designers? If so – why? If not – why?

   Areas for the categorisation of responses:
   a. Boys don't have the knowledge about dresses: gendered skill/ability expectations
   b. Gendered career expectations
   c. Gendered role expectations
   d. To establish conformity to societal stereotypes of scientists

7. Most times, when a scientist/engineer is pictured in a magazine/film is 'it' a man or a woman? Why is this so?
   Areas for the categorisation of responses:
   a. Stereotypically gendered images of scientists in the popular media
   b. Socialisation and culture's effects on APB's

8. Who are the leaders in the class in cases of controversial discussion and decision-making?
   Areas for categorisation of responses:
   a. This is an attempt to establish the dynamics of the interaction in the class. In times of controversy – who predominates – males or females
   b. Are the boys taking the decision making/leadership roles.

9. Why do they think as many girls are not following scientist careers (like engineers) as are boys?
   Areas for the categorisation of responses:
   a. Attempts to establish gendered stereotyping of careers and the roles that genders are expected to fulfill.

10. Why are more boys than girls taking careers like automotive mechanics?
    Areas for the categorisation of responses:
    a. Gendered stereotyping of socially accepted roles for men and women

11. Do they prefer a male or female science educator?
    Areas for the categorisation of responses:
    a. Connection between science and gender(gendered stereotyping of careers)
    b. Connection between socialisation and expected roles genders.

C. Reflections of the Interviewers

AKIEDAH HOOSAIN

REFLECTION: ON THE SURVEY

The survey was conducted at a high and primary school in Mitchells Plain. I was privileged to be able to conduct interviews with Grades 7, 8 and 9 learners. The survey was well planned and constructed; it is obvious that lots of preparation had gone into the dynamics and presentation of the questionnaire. However, I feel that some questions to some extent was complex and difficult to interpret by some learners especially Grade 7 and 8.

I found that learners from the lower grade were unprepared for the questionnaires. These learners where placed in a classroom that was cramped and crowded. This I feel had a great impact on the child's frame of mind and personal space. After I had explained my purpose for being there and read the questionnaire with them the session became less tense. In comparison to the Grade 8 and 9 learners, this session with the Grade 7 learners tended to be longer. They found the questionnaire too lengthy to tackle but they tried their best to answer all the questions. Explaining certain words and terminology also became time consuming. The Grade 8/9 completed the questionnaires within a shorter time period. This could be that they happen to be more matured, they more familiar and comfortable with me or because they were well prepared for the session way in advance.

With reference to the interviews, it becomes apparent that young people are by nature very sincere, genuine and honest when it comes to talking about themselves. This valuable information is evident in the body language, facial expression, report and assertive behaviour. Some kids I think enjoyed the interview more than the questionnaire. I discovered that the way the questions where posed was as important as the question itself. In other words, during the interview it became important how the question was asked and how it was phrased to the learners i.e. one's approach and tone of voice played a great role in creating a safe environment and atmosphere. When learners felt comfortable, their responses were spontaneous. I believe that if the interviews were conducted in an environment other than school, I would have received better interaction and responses from learners. It was obvious that regular interruptions and disturbances e.g. intervals, school bell, regular intercom announcement distracted the learners. I would recommend that a more favourable and child friendly environment be used for interviews of this nature.

It was a pleasure and a worthwhile experience to have been part of this research.

Hi Mr Gasant
Firstly, I would like to thank you for the opportunity to be part of your research.

The interviews took place at school which under normal circumstances is a fairly structured environment. Sirens indicating the start of next period and next task at hand (intervals or a scheduled classroom activity etc.) could possible - even on a subconscious level have influence both me and the interviewee. I tried as far as possible to make the interviewee relaxed but a siren indicating the next period could possibly have influenced (rushed) the interview. I wonder how doing the interviews in a neutral environment without any sirens or "school related stuff" would have influence the outcome.

Personally I don't think it would have changed the outcomes as I feel the interviewees were fairly honest in their responses although we might have gotten some deeper insight or more expanded responses if we were not too conscious of the time.

I feel the level of language of the questions was fair and I also tried to pose the questions as though we were just having a conversation instead of conducting an interview.

On a personal level I would have liked to explore the influence of modeling (parent behaviour) on the child in more depth. To what extent does the choices and behaviour of parents influence the career choices of the child?

The reason for this is that I am the father of two girls who both show talent and interest in science-related careers.

As a father I know that I would not be around to provide for them forever. A good education and the pursuit of a career would give them the security they need and give me the peace of mind I need.

On the other hand my wife has sacrificed a career in banking in order to be a stay at home mom for them. This has had its benefits for the family as a whole. My wife was and still is the one who creates a space and structured environment for them to engage in educational activities after school. She was also the one who laid the foundations for basic literacy and numeracy for both our daughters. This shows in their above average performance when assessed against their peers.So having a stay at home mom really has its benefits.

So now I wonder. Are they going to pursue careers and give me peace of mind or are they going to follow mom's example and be nurturers and caregivers ?

Rodney Johnson
Curriculum Advisor: Tourism
Metro North Education District

D. UWC ethical considerations form

SR1

- **UWC RESEARCH PROJECT REGISTRATION AND ETHICS CLEARANCE APPLICATION FORM**

- **B. PARTICULARS OF PROJECT**
- PROJECT NUMBER: TO BE ALLOCATED BY SENATE RESEARCH COMMITTEE:
- EXPECTED COMPLETION DATE: **March 2009**
- PROJECT TITLE: - - **GENDER EQUITY AND THE PARTICIPATION OF GIRLS IN SCIENCE EDUCATION: AN EXAMINATION OF THE ATTITUDES, BELIEFS AND PERCEPTIONS OF SCIENCE OF A GROUP OF GENERAL EDUCATION AND TRAINING (GET) PHASE LEARNERS IN THE METROPOLE SOUTH EDUCATION DISTRICT IN MITCHELLS PLAIN.**
THREE KEY WORDS DESCRIBING PROJECT: **GENDER** **EQUITY** **SCIENCE**
PURPOSE OF THE PROJECT: **To examine the attitudes, beliefs and perceptions of Science of GET learners in the Metropole South Education District in Mitchells Plain.** M-DEGREE: D-DEGREE: **Ph. D.** POST GRADUATE RESEARCH: **Yes**
- **C. PARTICULARS REGARDING PARTICULAR RESEARCHERS**

	FAMILY NAME:	INITIALS:	TITLE:
PRINCIPAL RESEARCHER:	**GASANT**	**M. W.**	**Mr.**
OTHER RESEARCH PROJECT LEADERS:	**None**		
OTHER CO-RESEARCHERS:	**None**		
THESIS: STUDENT RESEARCHER:	**None**		
THESIS: SUPERVISOR:	**Professor Tamara Shefer**		

This application will be considered by UWC Faculty Board Research and Ethics Committees, then by the UWC Senate Research Committee [SR]. SR may also consult outsiders on ethics questions, or consult the UWC ethics

subcommittees, before registration of the project and clearance of the ethics. No project should proceed

A. PARTICULARS OF INDIVIDUAL APPLICANT				
NAME: **Mogamad Waheeb GASANT**	TITLE: **Mr.**			
DEPARTMENT: **Women and Gender Studies**	FACULTY: **ARTS**			
FIELD OF STUDY: **Gender in Education**				
ARE YOU:				
A member of UWC academic staff?	Yes	☐	No	√
A member of UWC support staff?	Yes		No	√
A registered UWC student?	Yes	√	No	☐
From outside UWC, wishing to research at or with UWC?	Yes		No	√

before project registration and ethical clearance has been granted.

C. GENERAL INFORMATION

STUDY LEAVE TO BE TAKEN DURING PROj
ECT (days): **72 Days in 2008**

IS IT INTENDED THAT THE OUTCOME WILL BE SUBMITTED FOR PEER REVIEWED PUBLICATION?
YES √ NO ☐

COMMENTS: DEPARTMENTAL CHAIRPERSON:

SIGNATURE OF THESIS STUDENT RESEARCHER – WHERE APPROPRIATE:

DATE

SIGNATURE OF THESIS SUPERVISOR – WHERE APPROPRIATE:

DATE

SIGNATURE OF PRINCIPAL RESEARCHER – WHERE APROPRIATE:

DATE:

SIGNATURE OF DEPARTMENTAL CHAIRPERSON:

DATE:

NOTE: THESE SIGNATURES IMPLY AN UNDERTAKING *BY THE RESEARCHERS*, TO CONDUCT THE RESEARCH ETHICALLY, AND AN UNDERTAKING BY THE THESIS SUPERVISOR (WHERE APPROPRIATE), AND THE DEPARTMENTAL CHAIRPERSON, TO MAINTAIN A RESPONSIBLE OVERSIGHT OVER THE ETHICAL CONDUCT OF THE RESEARCH.

Please type below, or attach a typed document, usually between 500 and 5000 words, setting out the purpose and process of the research. Please include a clear research ethics statement. The onus is on the applicant to persuade UWC that the research will be conducted ethically. This will normally require evidence of an up to date research ethics literature search in the particular discipline; evidence of what the world standard ethical practice is, in the particular discipline; an explanation of how the proposed research is to be conducted ethically; a detailed justification of any proposed departure from world standard ethical practice; and a clear undertaking to conduct the research ethically. It may be useful also to agree to conduct the research in line with the published ethical rules of a national or international disciplinary association. UWC reserves the right to stop or suspend any research undertaken by its staff or students, or by outsiders on its property or in association with it, if the research appears to be unethical.

E.1 THE PURPOSE OF THE RESEARCH

The purpose of the research is to ascertain what the attitudes, beliefs and perceptions are of Grade 7 to nine learners are towards science and where these emanate from. The research aims to determine the effects of socialisation and culture, also in the school environment, on the attitudes, beliefs and perceptions of science of the learners in Grade 7 through nine.

E.2 THE PROCESS OF THE RESEARCH

The overall research approach will be to establish the socio-economic and educational backgrounds of the learners and their general attitudes, beliefs and perceptions of science and then to attempt to explore in more depth, via in-depth interviews their attitudes, beliefs and perceptions of science and their context.

A quantitative survey will be administered to two hundred English medium, Grade 7, boy and girl learners when they visit the school to be tested in order to establish their academic backgrounds before entering secondary school. The learners come from primary schools in the vicinity of Rocklands Secondary School in Mitchells Plain. They are drawn mainly from the following primary schools: Westville, Rocklands, Duneside, Parkhurst, Spineview and Ridgeville. All the schools are situated in Metropole South which is an educational district in Mitchells Plain, Cape Town. The majority of the residents in Metropole South educational district are from the lower middle class and were classified Coloured according to the Apartheid racial classification and therefore the educators administering the qualitative in- depth semi-structured interview will be from this group.

The survey will be conducted on the twenty eighth of March 2007 and will be used to establish the biological, socio-economic, cultural and educational backgrounds of the learners. The survey questionnaire will measure their attitudes, beliefs and perceptions of science with a particular focus on the gendered components. The survey will also be administered to two hundred grade eight and two hundred nine learners from Rocklands Secondary School on twenty eighth March 2007.

A qualitative, in-depth, semi-structured interview will be conducted with fifteen of the learners in this group who will be selected at random, to attempt to establish where their attitudes, beliefs and perceptions of science, in the context of the group's social, educational and economic profile, stems from and who or what influences these attitudes, beliefs and perceptions. The in-depth interviews will seek to establish whether there have been changes in the attitudes, beliefs and perceptions of the girls towards science from year to year and grade to grade. The in-depth interviews will also seek to establish what the reasons are for these changes are and where they stem from.

Whilst the quantitative questionnaire will be conducted by male and/or female research assistants who in all probability will be educators, the in-depth qualitative interviews of the fifteen learners drawn from the participants in the questionnaire survey will be conducted by young, Coloured, female research assistants who will most likely be tertiary education students selected from this ethnographic, sex, age-group in order to compensate for the possible intimidation of the girls learners by older, male interviewees from a different ethnographic grouping.

The purpose of the choice of interviewers is to make the interviewees feel emotionally comfortable and trusting when they respond to questions regarding their attitudes, beliefs and perceptions of science, choice or not of science as a subject in the FET phase of their education or a career in a science field which might have been subject to parental or other adult influence. This is being done to illicit responses from the girls learners which, in the opinion of Kelly, Burton and Regan takes account of the ..."the complex interplay of multiple sources of oppression (and areas of privilege) in women's lives" (1994:28). Edwards refers to 'sex-based trust' between women researchers and women interviewees (1990:486)

The aim of utilising young, female, Coloured interviewers is also to foster interactional dynamics which would promote responsiveness amongst the interviewees and to break down any hierarchical relationships which might be the case if older, male interviewers were used and to develop the 'inter subjectivity' suggested by Kelly, Burton and Regan (1994:34). They go further and refer to a 'set of presumptions' viz. that

- women want to share their experiences with other women;
- that this is always of personal benefit and that the sharing of gender will enable any difficult or painful accounts to be dealt with sympathetically;
- and effectively (1994:35).

Wolf (1996) regards the possibility of unequal hierarchical status between male interviewer and women interviewee as an issue of power. Edwards (1990) and Wolf (1996) refer to the exploitative possibilities of the unbalanced power situation stemming from differences in gender in fieldwork.

The need for interviewers to be selected such that they are immersed into the culture of the interviewee is also recommended by Warren (1988:13) who terms the practice 'cultural contextualisation'. Warren (1988) in fact mentions the skin colour of the field worker as a crucial factor in the interviewers need to fit into the culture of the interviewee. Wolf (1996) restates the idea of cultural immersion as a way of downplaying privilege and difference in the in depth interview in feminist social science research and is in fact of the opinion that race may dominate interaction between researcher and the person or group being researched

E.3 ETHICS STATEMENT

E.3.1 Ethics literature search

An ethics literature search was conducted in the social sciences and the following sources were consulted viz.

1. Congress, E.P. & Lynn, M. (1994). Group Work Programs in Public Schools: Ethical Dilemmas and Cultural Diversity. Social Work in Education. 16(2): 107-114.

2. Corey, G., Corey, M.S. & Callanan, P. (1998) Issues and Ethics in the Helping Professions. California.Brooks/Cole Publishing Company.

3. De Vos, A.S. (1998) Research at Grass Roots: A Primer for the Caring Professions. Pretoria. Van Schaik.

4. Levy, C.S. (1976). Social Work Ethics. New York. Human Sciences Press.

5. Mouton, J. (2001) How to Succeed in your Master's & Doctoral Studies: A South African Guide and Resource Book.Pretoria. Van Schaik

6. South African Council for Social Service Professions.Policy Guidelines for Course of Conduct, Code of Ethics and the Rules for Social Workers. Pretoria.

E.3.2 Explanation of how the Research is to be done Ethically

In the investigation care will be taken to avoid any emotional or psychological harm to the respondents during the survey questionnaire or in the conducting of the in depth interviews.

The learners and their parent or legal guardians will be informed about the research and consent will be elicited from the learners as well as their parents/guardians via consent forms to participate in the research.

Interviewers and the researcher undertake to regard the responses of learners as private and their privacy will in no way be breached or violated. Learners and their parents/guardians will be assured of their anonymity and confidentiality.

The interviewers would need to be competent and their actions would need to be subject to ethical and moral standards as required by education authorities and national standards for conducting research amongst learners.

There would need to be collaboration and co-operation between the researcher and the sponsors of the research and the University of the Western Cape.

The findings of the research would need to be made available to the sponsors and the University of the Western Cape as well as the education authorities whose permission for the conducting of the research has been applied for. The findings will also be made available to the learners and their parents/guardians on request.

The results of the research would need to be handled objectively and the integrity of the research will be protected at all times. Absolute care would need to be taken that interviewers do not fabricate or falsify data or findings.

In the publishing of the research care would need to be taken to subscribe to ethical publishing practices.

The research – it's procedures and process would need to be transparent in that it would need to be communicated to the sponsors and the University of the Western Cape. The results of the research would also need to be able to be disseminated freely and openly subject to the conditions of the sponsors and the University of the Western Cape. The results of the research will also be subject to full disclosure subject to the conditions of the sponsors and the University of the Western Cape.

There is awareness that the research will be conducted with learners who are regarded as a vulnerable group and in the event of any emotional issues emerging, referrals to counselors or other resources will be made.

E.3.3 Evidence of What the World Standard Ethical Practice is in Social Sciences

See E 3.6

E.3.4 Justification of any Proposed Departure from the World Standard Ethical Practice

It is not envisaged that there would be a need to depart from the World Standard ethical practice but if it is required, a justification would be given and the supervisor, sponsors and University of the Western Cape would be consulted.

E.3.5 Undertaking to Conduct the Research Ethically

University of the Western Cape
Bellville 7530

I, Mogamd Waheeb Gasant, Identity number 501122 5113 085 hereby undertake to conduct the proposed research ethically according the ethical rules, guidelines and standards of the University of the Western Cape.

.....
M. W. Gasant
05/02/2007

E.3.6 Published Ethical Rules of National/International Disciplinary Association

The following published national guidelines on ethics and ethical practice were consulted:

1. South African Council for Social Service Professions
2. The Health Professions Council of South Africa
3. Internet sites http://eduserve.hscer.washington.edu/bioethics/topics/resrch.html and http://www.sshrc.ca/english/programinfo/policies/ethics.html were accessed to ascertain what World standards of ethical practice in social science are.
4. The Medical Research Council
    a. Ethics issues in qualitative research
    b. Assessment of the ethics of research
    c. Monitoring the conduct of research
    d. Appendix 1: MRC checklist: quantitative research
    e. Appendix VI: Declaration of Helsinki (World Medical Association Declaration of Helsinki: Ethical Principles for Medical Research Involving Human Subjects)

.....
Mogamad Waheeb Gasant
05 February 2007
Form issued by: Professor Renfrew Christie, UWC Dean of Research, February 2002. (959 2949; 959 2948 secretary, 959 3170 fax, and email: rchristie@uwc.ac.za)

D. WCED application to conduct research at public schools

Navrae Enquiries Imibuzo	Dr RS Cornelissen		Wes-Kaap Onderwysdepartement
Telefoon Telephone Ifoni	021 - 467-2286		Western Cape Education Department
Faks Fax Ifeksi	021 - 425-7445		ISebe leMfundo leNtshona Koloni

APPLICATION TO CONDUCT RESEARCH IN PUBLIC SCHOOLS WITHIN THE WESTERN CAPE

Applicant details					
Title:	Mr.	**Surname**	GASANT		
First name(s):	Mogamad Waheeb			**Gender:**	Male
Name of organisation (directorate if WCED):	Rocklands Secondary School				
Contact person:	Mr. M. W. GASANT				
Address:	cnr Kim & Orion Roads, Surey Estate, Athlone, Cape Town			**Postal code:**	7764
Telephone number:	021-6331912	**Cell number:**		**731987837**	
Fax number:	021-3911653	**E-mail address:**		mwgas@hotmail.com	
Name of institution:	Rocklands Secondary School				
Student number:	2653891	**Degree/ Diploma:**	PhD		
Supervisor's name:	Professor Tamara Shefer			**Tel no of supervisor:**	021-9593360
Year of registration:	2006 January	**Year of completion:**	2010 October		
Specialisation:	Science Education			**Faculty:**	Women and Gender Studies

Title of research: **GENDER AND PERCEPTIONS OF SCIENCE AND SCIENCE EDUCATION: A CASE STUDY IN MITCHELLS PLAIN**

Research question: What socio-cultural factors as expressed in the participant's attitudes, beliefs and perceptions of science that impact on girl learners such that their participation in science lags behind that of boy learners.

Respondents:	girls and boys in grades seven, eight and nine
Name(s) of education institution(s):	

Westville Primary, Rocklands Primary, Duneside Primary, Ridgeville Primary, Parkhurst Primary, Rocklands Secondary, Lantana Primary, Spineview Primary

Research period in education institutions:	June 2008 to December 2008		
Start date:	2008 June	**End date:**	2008 December

Signature: M. W. Gasant (original completed form will follow) **Date:** 2008 June, 9

FOR OFFICIAL USE ONLY

Date approved:_____ Approved by:_____

Reference number:_____

F. Personal letter to conduct research at public schools

PRINCIPAL/PRINSIPAAL
M.W. GASANT

CEDARS AVENUE
ROCKLANDS
MITCHELL'S PLAIN
7798

TEL: 392-7139/0 FAX: 391-1653

CEDARSLAAN
ROCKLANDS
MITCHELL'S PLAIN
7798

Mr. Cameron Dugmore
MEC: Education
WCED
Head Office
CAPE TOWN
8000

9 June 2008

Dear Sir

Permission to do Research

I am the principal of a Secondary school in Mitchells Plain and am a registered part-time Ph.D. student at the University of the Western Cape (UWC). My student number is 2653891. The tentative topic of my research is...

GENDER AND THE PERCEPTIONS OF SCIENCE AND SCIENCE EDUCATION: A CASE STUDY IN MITCHELLS PLAIN

The quantitative, survey questionnaire aspect of the research will be done starting in June 2008, using Grade 7 learners from surrounding primary schools who intend attending this Secondary school in 2009 for grade eight to twelve as well as 2008 grade eight and Grade 9 learners. This quantitative part will be followed by a qualitative in-depth interview of ten to fifteen learners from each of grades seven, eight and nine.

As is required by WCED guidelines for doing research at school, I shall obtain permission from the school's governing body, parents (of the learners) and the learners themselves before commencing the research.

The research topic is particularly relevant since our school is one of the original one hundred schools nationally who formed the first schools in the Dinaledi Science and Mathematics Project.

My supervisor is Professor Tamara Shefer from UWC and I intend completing the research in 2010.

.....
M. W. Gasant

G. UWC letter from supervisor to WCED

University of the Western Cape

Women's & Gender Studies Programme

Private Bag X17 Bellville 7535 South Africa
1. Telephone: (021) 959 2234/3487 Fax: (021) 959 1273
E-Mail: wgs@uwc.ac.za

Dr R.S. Cornelissen
Research Directorate
Department of Education
Western Cape

8 December 2006

Dear Dr Cornelissen

Re: PhD student: Mr Waheeb Gasant

Mr Waheeb Gasant is currently enrolled as a doctoral student at the Women's and Gender Studies Programme, Faculty of Arts, UWC, under my supersion. He has made good progress in his first year of study with his proposal near completion and will be continuing next year. I am happy to answer any further queries.

Sincerely

Tammy Shefer
Director/Professor
Women's and Gender Studies

H. Letter of consent from parents

Informed consent letter to parents/guardians

Women and Gender Studies
University of the Western Cape
Private Bag X17
Bellville
7535
Cape Town
……..2008

Dear Parent/Guardian

CONSENT FOR YOUR SON/DAUGHTER TO BE INVOLVED IN A RESEARCH PROJECT

I am a Doctor of Philosophy student in the Women and Gender Studies Department at the University of the Western Cape in Bellville.

I am conducting a study that examines the attitudes, beliefs and perceptions of science, of learners in the GET phase i.e. grades seven, eight and nine. With your and your son/daughter's permission, your son/daughter will be asked to complete a survey questionnaire regarding his/her attitudes, beliefs and perceptions of science **on ……2008.**

Please note that your son/daughter's identity will remain anonymous throughout the study i.e. his/her name will at no stage be revealed. Your son/daughter's participation in the study is not compulsory) and he/she may decide not to participate.

Kindly discuss your son/daughter's participation with him/her and if you are both agreeable would you please complete the return slip below and send it to school via your child.

THANK YOU

……
M. W. Gasant
Principal, Rocklands Secondary School

PLEASE COMPLETE AND SEND TO SCHOOL VIA YOUR CHILD ON ……

I, Mr./Mrs./Miss (INITIAL AND SURNAME) ……

father/mother/guardian of (LEARNER NAME) …… grade 7

hereby confirm that I understand the contents of this document and the nature of the study. I consent to my son/daughter participating in the research project.

I understand that he/she is free to leave the study if he/she wishes to do so.

(PARENT/GUARDIAN SIGNATURE) …… DATE: ……/…../2008

I. Letter of consent from learners

Informed consent letter to learners

Women and Gender Studies
University of the Western Cape
Private Bag X17
Bellville
7535
Cape Town

..... 2008

Dear Learner

CONSENT TO BE INVOLVED IN A RESEARCH PROJECT

I am a Doctor of Philosophy student in the Women and Gender Studies Department at the University of the Western Cape in Bellville.

I am conducting a study that examines the attitudes, beliefs and perceptions of science, of learners in the GET phase i.e. grades seven, eight and nine. You are kindly asked to participate in the study by completing a survey questionnaire regarding your attitudes, beliefs and perceptions of science.

You might then be selected to be interviewed in a more detailed manner (the Focused Interview) about your attitudes, beliefs and perceptions of science.

The first phase (the Survey Questionnaire) is expected to done in the period January to October 2008 and the second phase (the Focused Interview) in the period January to October 2008.

Please note that your identity will remain anonymous throughout the study i.e. your name will at no stage be revealed. Your participation in the study is voluntary (i.e. not compulsory) and you may decide not to participate.

Kindly discuss your participation with your mother/father/guardian and if you are both agreeable would you please complete the return slip below and hand it to your teacher.

THANK YOU

.....
M. W. Gasant
Principal
A Secondary School in Mitchells Plain

PLEASE COMPLETE AND SEND TO SCHOOL

I, Mas./Miss (INITIAL AND SURNAME) ..... in

grade ..... hereby confirm that I understand the contents of this document and the nature of the study. I consent participating in the research project.

I understand that I am free to leave the study if I wish to do so.

(PARTICIPANT'S SIGNATURE) ..... DATE: ...../...../2008

J. WCED Permission to do research

WESTERN CAPE
Education Department
Provincial Government of the Western Cape

EDUCATION RESEARCH

Ronald.Cornelissen@pgwc.gov.za
tel: +27 21 467-2286 fax: +27 21 425 7445
Private Bag x9114, Cape Town, 8000
wced.wcape.gov.za

REFERENCE: File number: 20061215-0042
ENQUIRIES: R. Cornelissen

Mr Mogamad Gasant
cnr Kim and Orion Roads
SURREY ESTATE
7764

Dear Mr M. Gasant

RESEARCH PROPOSAL: GENDER EQUITY AND THE PARTICIPATION OF GIRLS IN SCIENCE EDUCATION. AN EXAMINATION OF ATTITUDES, BELIEFS AND PERCEPTIONS OF SCIENCE OF A GROUP OF GENERAL EDUCATION AND TRAINING (GET) PHASE LEARNERS.

Your application to conduct the above-mentioned research in schools in the Western Cape has been approved subject to the following conditions:

1. Principals, educators and learners are under no obligation to assist you in your investigation.
2. Principals, educators, learners and schools should not be identifiable in any way from the results of the investigation.
3. You make all the arrangements concerning your investigation.
4. Educators' programmes are not to be interrupted.
5. The Study is to be conducted from **01st March 2007 to 30th December 2008**.
6. No research can be conducted during the fourth term as schools are preparing and finalizing syllabi for examinations.
7. Should you wish to extend the period of your survey, please contact Dr R. Cornelissen at the contact numbers above quoting the reference number.
8. A photocopy of this letter is submitted to the Principal where the intended research is to be conducted.
9. Your research will be limited to the following schools: (primary schools in Mitchells Plain)
10. A brief summary of the content, findings and recommendations is provided to the Director: Education Research.
11. The Department receives a copy of the completed report/dissertation/thesis addressed to:

    The Director: Education Research
    Western Cape Education Department
    Private Bag X9114
    CAPE TOWN
    8000

We wish you success in your research.

Kind regards.

Signed: Ronald S. Cornelissen
for: **HEAD: EDUCATION**
DATE: 18th January 2007