WOMEN IN SET: EXPLORING THE FACTS

A report prepared for The South African Reference Group for Women of The National Advisory Council on Innovation, under the auspices of the Department of Science and Technology

by

TARA RESEARCH & EQUITY CONSULTANTS

Women in SET Summary Report

Introduction and Background to the Study

In 2004 the National Council for Innovation (NACI) published a study entitled *Facing the Facts: Women's Participation in Science, Engineering and Technology.* The study found that in most Science, Engineering and Technology (SET) disciplines, and in the sector as a whole, women are significantly under-represented. In addition, only 6.4% of a sample of 17 000 research projects in the public sector was found to have an explicit gender perspective. In short, there was less science being produced by women and for women than by and for men.

To work towards correcting these imbalances greater insight into their determining conditions was required. Consequently NACI, the South African Reference Group for Women (SARG), and the Department of Science and Technology (DST), commissioned a study exploring the experiences and perceptions of women working in the SET sector. This report presents the findings of that study, and the subsequent recommendations for policy formulation.

The Study Objectives

The objectives of the study were:

- To explore the possible reasons for why women are under-represented in the SET sector.
- To document perceptions and suggestions for increasing the representation of women in SET.
- To explore the possible reasons for why so little research output from the SET sector has an explicit gender perspective.
- To prepare policy recommendations based on the findings of the study.

To achieve these objectives three research questions were proposed:

1. Why is science not regularly produced by women?
2. What are the perceptions of current and suggestions for additional interventions that may improve the representation of women in SET?
3. Why are so few scientific developments produced for women?

The research questions would inform the design of an interview schedule, and would also guide the analysis of the interview transcripts.

The Sample and Method

One hundred and thirty six in-depth interviews were conducted with respondents who were either working or had worked in the SET sector. The sample consisted principally of women, although men were included because of their influential roles as women's colleagues and research agenda setters in the sector.

Interview transcripts were analyzed and responses arranged in themes. Not all themes carry equal weight: some perceptions are widespread while others are quite unique; some themes predominate with certain groups while being absent from others. Accordingly the

relative prevalence of themes had to be noted across specific demographic variables: gender, population group, level of qualification and type of organization worked for (academia, industry or science council). The presentation of findings and recommendations, in both the summary and full report, is shaped by the relative importance of themes as they are reflected in the research data and supported or contested in the literature.

The sampling framework (illustrated in Figure 1) prioritised reach across the SET sector in an attempt to ensure that no substantial sub-sector would be omitted or demographic specific issues go undetected.

The primary research findings established through the interview process are supported by a literature review. The literature review provides essential context for understanding and interpreting qualitative data sourced, as it is, from a very limited sample.
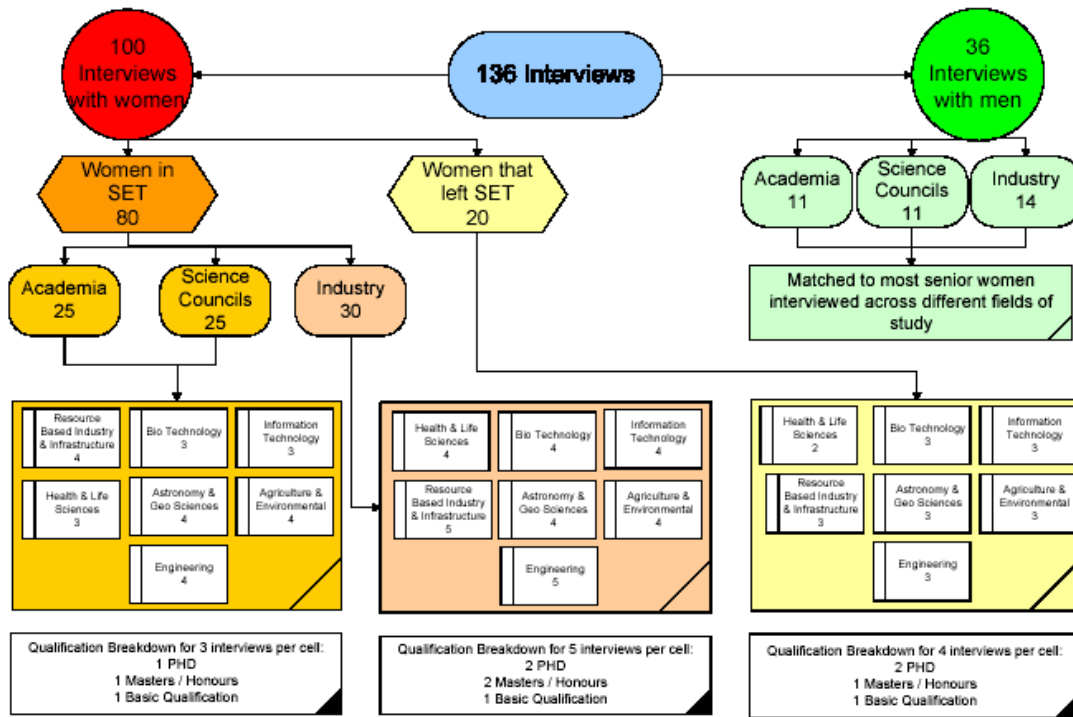

Figure 1: Sampling Framework

Summary of the Literature Review

The literature on women in the science, engineering and technology sector addresses both issues of gender representation, as well as the production of research with an explicit gender perspective. Pertinent points are summarized in the sections following, while a more comprehensive discussion of the content is available in the comprehensive version of this report.

Science by Women: Barriers to representation

The under-representation of women in SET is a reality confirmed in studies emerging from around the world. A number of explanations for this state of affairs has been posited in the relevant literature, and are summarised here.

Gender Stereotyping in Family, Education and Media

Regardless of their source, negative attitudes toward science are linked to science anxiety, which in turn decreases the likelihood of studying or achieving in science (Brownlow et al, 2000). The socialising role played by parents has a significant impact on the study and career choices of young women, as parental expectations of gender-related abilities serve as the mechanisms by which children come to understand how to behave (cf. Eagly, 1987).

Teachers have a similar level of influence. They "may tacitly discourage science studies for girls (Rennie & Dunne, 1994), as some teachers view science as incongruent with the feminine sex role (Kahle et al., 1993). Furthermore, teachers believe that boys have more ability than girls in math and science, and perceive that girls' achievement in these areas is due to effort rather than innate capability (Jussim & Eccles, 1992). These perceptions have an impact on classroom interactions (Rech, 1996), as teachers ask girls few difficult questions, direct comments to them less often, and avoid using girls in demonstrations (Chenan & Siweya, 1996; Kahle et al., 1993).

An interesting finding from the Chaung and Lee (2003) is that the attitude of a women's husband was a strong determinant of a women's attachment to the labour force. They argue that a husband's attitude toward traditional gender roles would dominate women's work decisions. The different gender expectations on men and women have impacted not only on the exclusion of women from SET careers but also their progression in these careers. Acker and Armenti (2004) argue that the dominant discourses among academics, and the expectations at undergraduate level "are those that feature competition, individual achievement, striving for continuous improvement and placing of responsibility for success in one's own hands" which does not fit with female socialisation and hence places women at a distinct disadvantage when compared to men. Negotiating the academic institutions is also so much easier for men, and that much more challenging for women because the "(1) rules are made by men, (2) young men are socialized to those rules and further socialized in graduate school. They have learned the strategies, (3) most women have not been socialized to be autonomous, and therefore they have difficulty figuring out the rules; and (4) most male advisors do not teach women the strategies necessary to succeed" (Etzkowitz et al, 1994).

The media too is a key role-player in gender stereotyping and suggesting what appropriate gender-role behaviour is. The impact the media has on young people can not be under-estimated (Brownlow, 2000).

The Structure and Organisational Cultures of the Research Community

Braithwaite (2001) suggests that "the most prestigious research centres tend to be the most male-dominated in terms of staff, and often the most masculine in their culture. …there is indeed a generally higher participation of women in science and research on the 'fringes' of Europe and lower figures as we go toward the centre." In most institutions, "women are expected to follow a "male model" of academic success involving a total time commitment to scientific work and aggressive competitive relations with peers" to which many women are unwilling to adapt (Etzkowitz et al, 1994). However there are women who do adapt to this culture. They are perceived as insensitive by, and on occasion openly hostile to, other women. They also usually see the system as favourable to women, put in many hours, don't usually have children, and do not think the status of a woman is an issue (Etzkowitz, et al, 1994).

It was found that there was an urgent need to modernise human resource management policies in the universities and research institutes of the Helsinki group of European countries. There was "… lack of transparency in appointment procedures, the over-reliance on old boy networks, nepotism and patronage among people working in science and a concern that the old boy networks may be more important than merit in determining the allocation of opportunities" (Rees: 2001).

Acker and Armenti (2004) assert that the underlying structure and ideology of academic institutions works to the disadvantage of women, an argument potentially applicable to other institutions. Institutions and individuals who advocate for neutrality in policies are unaware of the risks of indirect discrimination that can result. The MIT report on the status of women science faculty members indicates that "…gender-blindness blocks every claim made by women, who find themselves facing specific circumstances that justify differential treatment. In order to counter this attitude, it is necessary to make visible and acknowledge the specific features of women compared to men, and vice versa" (European Commission, 2003). If policies remain gender-neutral, the danger is that it continues to benefit men since "On the one hand, nothing changes and the same problems persist: for example, the glass ceiling or the hold put on women's career by pregnancy. On the other hand, women might feel encouraged to adopt male-type behaviour at work…" (European Commission, 2003).

Braithwaite (2001) suggests there are often hidden gender biases in selection tools used for grants. A number of studies have indicated that age restrictions as part of the conditions for grant funding (e.g. only under 30's can apply for a particular grant) can be discriminating to women's mobility "because of the different lifecycles of women and men and the greater discontinuity in women's careers" (Braithwaite, 2001:151). In South Africa, "between 1995 and 2001, women consistently received far fewer research grants and scholarships from the NRF than did men: in 2001, women were the recipients of 21% of the research grants, and 42.5% of the Masters and Doctoral scholarships" (NACI, 2004). However, things were different in regards the MRC grants where women received

a larger number of Masters and Doctoral scholarships, and self initiated research grants, than did men because the MRC focuses on the health sciences where there is a general over-representation of female students and staff (NACI, 2004).

Negative Dynamics in the SET Workplace

There are particular modes of exclusion within the workplace that constitute women's experience of SET. The Helsinski group found that there is a lack of gender balance in decision making in areas such as "…what constitutes science and scientific excellence, how science budgets should be allocated, who awards grants or prizes, who makes appointments or decides on promotions" (Rees, 2001: 53). Informal activities outside of the department are also often linked to traditional sex role activities and venues. In one department in a related study, a regular pick-up basketball game was a site for exchange of informal comments on research activities along with visits to a male-oriented local bar. Inevitably a female faculty member felt excluded from "the club" (Kemelgor, 1989)".

There is a tendency in some SET institutions to devalue women's contributions in various ways: by not crediting women for work they have done, ignoring her work, excluding women from important events. Etzkowitz et al (1994:10) confirm this when they state, "As part of the cumulative thwarting of a female professional identity, devaluation of women's scientific contributions has been found to be widespread (Benjamin, 1991). It takes many forms, including crediting the male partner in scientific collaborations and ignoring the work of women (Scott, 1990)."

The pressure women place on themselves to perform because of internalized gender expectations and the sense that they are 'outsiders' in a male-dominated world, increases women's exhaustion and potentially impacts on their retention and burnout. Women feel that "As relative newcomers, they are 'outsiders in the sacred grove' (Aisenberg & Harrington, 1988) and subject both to a felt need to prove themselves up to the task and to the contradictory and conflicted expectations of colleagues and administrators.

The conflict between women's careers and household duties and child care responsibilities is an ongoing source of stress, time-management and career planning challenges. There is still and unequal distribution of family responsibilities between men and women, with women carrying the bulk of the burden (European Commission: 2003: 53). The results of a study in Taiwan confirm that "the presence of young children in the family has a negative influence on their mothers' labor market commitment" (Chaung, Lee, 2003). The European Commission (2003: 53) study also argues that "Pregnancy and children are the issues that most often create difficulties for women" and their career development.

Etzkowitz et al, (1994: 4) outline three specific points in a woman's life-cycle when women's work is negatively affected by marriage and children. They are when "having a child during graduate school, marriage at the point of seeking a job, and pregnancy prior to tenure. In addition, we found some disparagement of marriage during the graduate student career. Women, but not men, are sometimes thought to be less than serious about their science if they do not stay single while in graduate school" (Etzkowitz,et al, 1994: 5). Hence institutions make little, if any, allowance for the child rearing and other responsibilities of women, which men often do not carry, outside of the work environment.

The impact of family responsibilities on the career development of women should not be under-estimated as "Mincer and Polachek (1974) argue that withdrawal from the labor market influences wages through human capital depreciation and underinvestment in on-the-job training" (Chaung, Lee, 2003). At the same time, it is important to acknowledge that family dilemma's impact differentially on women depending on age, whether the women had a partner and the age of the children (Acker and Armenti: 2004). Older women have usually already dealt with the conflicts around domestic demands and career paths, whilst younger women are caught between having children and securing tenure. As a result many women delayed having children until they got tenure (Acker and Armenti: 2004). Childcare and access to day care is another huge issue for younger women in the Acker and Armenti (2004) study. These women spoke about "high levels of stress, exhaustion, and sleeplessness associated with combining the building of an academic career with bringing up young children".

Braithwaite (2001:151) suggests that "Maternity care and educational provision can also have a differential impact, as well as appropriate housing (for families) and social security provisions". The Women Returners' project in the UK highlights that finding suitable and affordable childcare facilities and work-life balance issues are barriers for women returning to work – issues that are common with women in SET (DTI, 2003). Years of work and education level are correlating factors to women's return to employment and retention. A study in Taiwan indicated that women with longer work experience prior to the first birth and "women with a higher level of education are more likely to have a stronger labor market commitment". So barriers to women's development may differ depending on geographical location, educational attainment, among other factors (Chaung, Lee, 2003).

Science by Women: Factors facilitating representation

Factors that enhance the representation of women in the SET sector have been identified in the literature and are summarized below.

Personal Preferences

Women's career choices across sectors, as well as within SET are strongly determined by personal factors such as values, abilities and preferences. Studies indicate that in Europe, women scientists tend to prefer public sector work. Their rationale is that the public sector focuses on basic research and values individual achievement, whereas industry favours applied science and is team oriented. (European Commission, 2003). Moreover, industry is seen as more stressful and fast-paced, whilst university research is more relaxed. The most decisive factors in women's preference of the public sector are flexible work hours and intellectual freedom (European Commission, 2003).

Women's sectoral preferences in the USA are substantially different compared to those in Europe, but the rationale informing choices is similar. Women in America seem to prefer working in industry as opposed to academia. Etzkowitz et al's (1994: 10) study with women in academia indicated that "A majority of women graduate students in all departments studied reported that they intended to pursue an industrial rather than an academic career since it was more compatible with family life. As an informant, comparing the two scenes, concluded: Women will go in to industry. It's 9 to 5. It's more

flexible. They have daycare and childcare. There are federal rules they have to abide by in terms of maternity leave whereas in academics you're on your own. The support systems exist [in industry] and it's the only way you can [have a family]".

Role Models and Mentoring

According to Mbandla (2001) many women who had been involved in activist activities expressed a need for career planning and mentoring now that they are re-focussing on their individual careers. In academia it was found that women prefer women mentors, and "Women graduate students seek out women faculty members as advisors in hopes of finding a sympathetic mentor, while male graduate students sign up with a woman only after she has achieved a distinguished position in the field" (Etzkowitz et al, 1994). Beyond strictly professional issues women mentees are concerned with the interpersonal quality of the relationship and seek a sympathetic mentor (Dowdall, 1979)" (Etzkowitz et al, 1994: 15). Mentoring and networking is a useful strategy according to Baroness Greenfield's report (DTI, 2003) to retain women and increase their mobility, particularly in a male dominated workforce.

Moreover, the presence of women in SET professions can fulfill an important modeling function. However there are "Proportionally, few women are scientists or science teacher/professors (Acker & Oatley, 1993; Trankina, 1993), so there are few women scientists to serve as role models" (Brownlow et al, 2000: 5). Research has "identified the characteristics of successful women role models who integrated, "... professional and personal concerns" (Mokros et.al, 1981: 11). However, in the absence of role-models, women students are anxious about how to deal with problems and help then develop a path and identify the necessary steps in graduate school. Whilst for men the availability of a wide range of male role models they can potentially identify with increased their self-confidence.

Collectivity

Strategies utilised by women to cope with male-dominated, alienating environment include sharing their concerns and supporting each other. This emerged strongly in the Acker and Armenti (2004: 15) study where they "found some evidence of resistance and collective measures. There was a tradition of quiet sharing whereby women gave career advice to other women". Women higher in the ranks felt a particular responsibility to mentor and support women coming up the ranks. Women also developed networks of support and sometimes even unionised to strategise and empower women, for e.g. at one university women lobbied to get female representation on important university committees, whilst in another instance they united to get relevant policies such as maternity leave changed (Acker & Armenti, 2004).

Science for Women

Although not as prevalent as the issues of representation, the production of scientific output for the benefit of women is addressed in the literature. Some of the most pertinent points in this regard are summarized in the sections that follow.

The Need for Mainstreaming Gender in the Production of Research

Women scientists have long been criticising the curriculum and research agendas in their disciplines because of a gender bias in the choice of topics and theories which predominate, as well as gender bias in the production of knowledge itself (Bosh, 2001:65). Consequences of this gender bias include:

- Gaps in knowledge: Men are still taken as the norm in research (Klinge, 2001). Hence, "male bias in concepts and theories has had left large areas unstudied: domestic and unpaid labour in economics, the study of daily life in history, or conditions of concern to women in medicine, such as menopause and menstruation, mastopathy, anorexia and incontinence" (Bosh, 2001:66).

- Mis-use of experimental design results: Often the experimental design and choice of population in the design is gender biased (Bosh, 2001). Historically there is evidence of under-representation of women in health research, and in particular in pharmacological research (Klinge, 2001).

- Limited interpretation of research results: Research results are often (mis)interpreted based on traditional prejudices about men and women.

- Lack of science for the benefit of women: If science is to benefit women the beneficiaries of SET need to be clearly identified and kept in the forefront of developments in the sector. Women also need to be involved at all levels in the technology creation and commercialisation process (Marcelle, 1998: 18). It is also critical to recognise that women are not a homogenous category and SET products and services need to benefit women who may come from different levels of education, areas of residence, social, ethnic and racial backgrounds (Marcelle, 1998).

Research in the SET sector needs to keep the beneficiaries in mind and consider the social and cultural aspects of their products and services. To ensure women are included and receive resources Marcelle (1998) recommends that gender-aggregated statistics on beneficiaries of projects would be useful. It would be important for organisations to identify "the proportion of projects based on gender impact assessments, the proportion of projects working within a gender perspective, (and) the proportion of projects completed during the year that included a gender perspective at the evaluation stage" (Winberg, Bergh, 2001).

Why Women's Issues are Under-Represented in SET Research Agendas

There is a lack of awareness amongst SET workers about how their work impacts on the end-user and particularly men and women separately. This is related to the training of science students which is goal orientated, and leaves little space for the inclusion of social and cultural facets that impact on the lives of both men and women in their utilisation of science products and services. The prejudicial effect on women of this deficit in awareness is exacerbated by the under-representation of women in SET. Women do not advance to the top of the sector and therefore do not make the decisions.

The results of gender imbalance in decision making in the Water Affairs and Forestry sector for example, has been that men make decisions regarding the allocation of funds whilst it is women that actually utilise the resources and hence have the real knowledge about resources required. By their lack of participation women suffer the consequences of not having appropriate access to resources (Department of Water Affairs and Forestry, 1997: 6). More generally the value of a reflective culture that recognizes and interrogates its own values and norms is not widely appreciated in SET. Bartsch (2004) argues that it is important to incorporate "…an inquiry-based model with the goal-orientation model would train more science and medical students to consider how their trade impacts, both positively and negatively, the world around them".

However, the idea that just more women in the SET field in itself will create change is problematic and needs to be challenged, because women work in a socio-economic and cultural context that are not always supportive of their ideas, needs, and interests. As Schiebinger (2002: 389) based on her research in the health, primatology and archaeology sectors in the USA points out, "Introducing new questions and directions into the natural sciences requires more than simply increasing the number of women in a particular discipline: it requires long years of training in a discipline, gender studies, and feminist theory; it requires universities and foundations that provide funding for gender-responsible work, departments that recognize the work as tenurable, and so forth". Harding (1998); Keller (1985); and Longino (1996) argue that simply changing the characteristics of those involved in science is insufficient because the institutions of science need to problematised and the underlying social and cultural issues that exclude diverse groups needs to be challenged. They further state that "Without such an investigation, change in the institution of science or the academy will never occur" (Bartsch, 2004: 48).

This perspective is particularly telling when considering the funding regime that dictates much of the activity in SET.

The notion of engaging in research that does not discriminate against anyone is also problematic, and can lead to research not recognising diversity and gender differentiated needs. The argument that Meiners & Fuller (2004: 7) make about race, applies to gender as well: that to "have 'race neutral' educational change is not feasible, and as research has demonstrated it is not effective. Eisenhardt and Finkel (1998) found that race and gender neutral environments in the sciences are only neutral to the white males that construct that environment . . . In addition, questioning the choice to fund projects focused on people of color and/or women is connected to charges of 'reverse discrimination' and to larger critiques of affirmative action (Guinier 2003, McCarthy and Crichlow 1993)". Eradicating categories of analyses in research can be problematic in that the needs of differing groups are assumed to be homogenous, excluding deliberate sufficient consideration of women and other marginalised groups.

Very few publicly funded research and development projects consider the special needs and perspectives of men and women as separate. Whether research funders recognise the importance of the gender dimensions of research will be reflected in their policy and funding guidelines. However it has been suggested that there is a lack of socially responsive criteria guiding the approval of research proposals and research funding, which inhibits the development of engendered research agendas. Schiebinger (2002)

suggests that the guidelines for research proposals should include whether the proposed research will identify gender dimensions, and that this criteria is only valid if it is strictly enforced when granting funds. There are also no funding incentives for doing research by, with and for women. Projects which focus on women's empowerment in the ICT sector are usually inadequately resourced and most often suffer from uncertainty in project funding and resource allocation (Marcelle, 1998).

Main Findings

The Experiences of Women in SET

The following section discusses the themes relevant to the research question *Why is science not regularly produced by women?* It explores reasons for both the under-representation of women in SET and the apparent lower productivity of women (measured by number of publications) when compared with their male colleagues.

Qualifying for a career in the SET sector

Including the themes:
- Gender role education and conditioning
- Deficits in the provision of education
- Science anxiety
- Factors that encourage women to study in an SET related field
- Positive and negative experiences of gaining an SET related qualification

"I Studied at RAU. They were hugely supportive of females. I had good relationship with all lecturers and staff. I was also hugely supported by the dean of the faculty. I do believe as a female student – because you are a minority - you attract more attention. This stands you in good stead – it is easier to attract attention and impress. I cannot think of one incident where fellow students were nasty to females."

Gender role education and conditioning discourage women's participation in SET. Many interviewees agreed that a large number of careers are traditionally associated with a particular gender. These gender stereotypes are reinforced by teachers, parents and others, who inadvertently or deliberately discourage young women from embarking on a career in SET. In the experience of many respondents, career guidance and selection processes for study courses tend to perpetuate rather than challenge these stereotypes, further discouraging young women from educating themselves to enter SET.

Interviewees also spoke of deficits in the education and training facilities at schools servicing disadvantaged communities, which result in learners developing inferior language, mathematics and science skills. A lack of academic background and ability will limit course options at tertiary level. These conditions continue to prevail in many schools today, prejudicing a large pool of potential candidates for tertiary training in SET, including young women.

Interestingly, interviewees would associate education deficits with feelings of anxiety towards maths and science. Science anxiety is related to poor academic performance in and a negative bias towards science. Although science anxiety is not dependent on quality of education, it is plausible that shortfalls in their education would contribute to learners' science anxiety, exacerbating the disinclination towards studying SET related disciplines.

Mitigating these dissuasive influences are factors that encourage women to enter a career in SET. Those mentioned most often and described as most influential were a woman's preferences and aptitudes; being exposed to SET career information, education and activities; encouragement from a mentor figure, especially a parent; and real or perceived incentives such as bursaries, employment opportunities and earning potential.

"The field trips were especially rough. The guys wouldn't speak to me. Later they actually apologised to me. When I convince them I was

Obtaining a tertiary qualification in any SET field is challenging and the threat of attrition at this stage in the career path is considerable. Learners struggle with the strenuous academic demands and, certainly for those from disadvantaged backgrounds, financial concerns are a constant feature of their academic experience. For women studying in SET fields a negative academic experience was further characterized by perceived sexism from lecturers and especially male students, with few or no female classmates for allies. Interviewees maintain that discrimination heightens the risk of women abandoning studies in SET, compared with the risk of male learners doing so. Often women interviewees, who obtained a qualification despite a negative academic experience, would attribute their perseverance to restrictive circumstances. Due to financial concerns, family expectations or some other external limitation, they were not free to change their study direction. The idea of limited options for women is one that emerges repeatedly in this study.

Not all interviewees experienced their tertiary education negatively. A positive academic experience was generally associated with supportive lecturers, the company of female classmates, knowledge of female role models active in the field being studied, and an academic culture perceived to be, on the whole, free of gender discrimination.

Remaining in the sector

Including the themes:
- Women's suitability for SET
- Discrimination in the SET workplace
- Family versus a career in SET
- Reasons why women leave
- Reasons why women stay

"I think in certain positions women are a lot better than men, we tend to cope in stress situations totally different and we definitely tend to be more logical in certain scenarios than what guys are, they tend to get very emotional and egotistic with certain things".

Although there were interviewees rejecting any suggestion that women were not cut-out for careers in SET, there were others affirming commonly held prejudices arguing against women's suitability to the sector. These prejudices included associating certain jobs with a lack of femininity or insisting that the average woman's lack of physical strength, compared with the average man, was a handicap 'in the field'. In fact there are features of the working conditions in SET that inadvertently support such biases.

For example a number of interviewees reported arriving at field stations, building sites or mining compounds where no ablution facilities were provided for women. Technical equipment and machinery too, is often designed with men in mind, in some instances making them impossible for women to use. Difficulties with equipment are invoked as proof that 'a woman just can't do it' or as a pragmatic rationalization for appointing men exclusively to executing certain tasks. Lack of accommodation at a planning or design level is probably assumptive rather than deliberate, but it nevertheless disadvantages women and supports deliberate discrimination.

More recurrent than implications of women's inherent unsuitability to SET however, were references to an overwhelming, imposed handicap - having to continuously contend with gender bias during their education and in the workplace. Reported were a range of discriminatory behaviours, from the customary (patronization) to the concealed (sexual harassment). Between these two extremes interviewees located some compelling instances.

A fairly familiar complaint was that the better opportunities on the more exciting project teams were often held in reserve for men, by men. An element of discretion in assembling teams may be desirable, for a variety of reasons, but calculatedly or accidentally, it permits discrimination. Less frequent were accounts of contributions by young women scientists going unrecognized. The extent to which and even whether such exploitation is attributable to gender bias is not entirely clear, although its explanatory value is noteworthy. Certainly interviewees considered the fact that they are women a factor.

"I worked on a project, the results were patented and my name was not there. I only realised later I could have gone to my boss. I also contributed, I did most of the job and my name should appear on it."

Unsurprisingly, a constant theme was the challenge of reconciling family responsibilities with a career. Interviewees repeatedly described experiences of gender discrimination based on the conviction held by colleagues and superiors that an immanent pregnancy would soon ruin the woman's productivity. This perspective is remarkably ubiquitous, albeit in less explicitly misogynistic forms and, of course, simplistic. It ignores the fact that women, despite entrenched civil rights and apparent equal opportunities, may still be constrained by severely limited options.

For example, numerous women interviewees conceded that they remain obligated to fulfill traditional family roles. Even if they are not subject to rigid cultural expectations, the greater part of responsibility for family matters usually falls to them. Aside from complying with maternity leave legislation, few organizations make the necessary provisions (flexitime, child care facilities etc.) that would allow women to continue their

careers while fulfilling their familial 'duties'. The inevitable consequence is that many women feel bound to sacrifice an unaccommodating career for the sake of family.

Consequently, a woman's career is interrupted by pregnancy and child rearing. Even if she returns to work early, she continues to carry the greater share of family responsibility. If the work environment is unaccommodating her career will suffer. The negative impact on her career is exacerbated if her family is unsupportive of her professional life and aspirations. Add to this the fact that advancement in SET usually requires further studies, and we find women caught in a triple bind – work/family/studies – a constellation of demands that is very difficult to balance successfully.

"When I became pregnant I decided to stay at home for a while. At that stage we only had 2 weeks maternity leave. Maybe that's one of the things that women also struggle with . . . anyway; we had 2 weeks of maternity leave. You cannot have a child and recover in 2 weeks. So I resigned. Of course if I was a man it would not have happened."

Ironically, it is this precise scenario that keeps employers from investing in female employees, and a lack of investment in the special needs of female employees that perpetuates this precise scenario.

A work environment where equipment, facilities and sensibilities do not accommodate women, women's experiences of personal discrimination in the workplace, and the pressures of family commitments all contribute to women deciding to withdraw from careers in SET. Additionally interviewees mentioned that the level of reward, materially or otherwise, was not commensurate with the effort required to build a career in the sector. Not only was this factor responsible for women (and men) leaving SET, but fewer people were choosing SET as a career because of it. There were simply too few attractive career opportunities available in SET.

While most interviewees responded as if they agreed that attrition amongst women in SET was the dominant trend, there were a number who challenged this assumption. A number of interviewees insisted rather that women tend to stay in SET. Career fulfillment and career opportunities were cited as motivating factors for women to remain in the sector. These interviewees asserted that family, colleagues and superiors are inclined to be supportive of women's careers in the sector and that academia was particularly suited to women because the flexible hours allowed them to balance personal and professional responsibilities. A smaller group of respondents said that many women remain in SET because they are financially obligated and feel it is too late to make a career change. There was also the view that women stayed in SET because, although gender discrimination was a challenge, other sectors were even more biased towards women.

Progressing in SET

Including the themes:	*"I learnt how to out-write them, out-research them, out-lecture them and I learnt how to be slightly larger than life."*
• Men and other women as barriers to advancement • Further study as a barrier to advancement • SET as a sector of opportunity • The adapted woman	

As was to be expected, some interviewees maintained that in their experience men in senior positions deliberately resist women's promotion in the workplace, and habitually favor men while overlooking their female colleagues. This bias may be accidental, but where it is deliberate it is informed by a hard-wired prejudice that women are simply not suited to SET and their potential to contribute is dismissed.

"The attitude was women should be in the home, women don't take these sorts of jobs. In fact at my very first job I was given a comment by the general manager - he was a very autocratic person - and he said to several senior managers, 'it is ridiculous why should we pay her that much and she actually owns her own car'. That shows those were the expectations."

More surprisingly though, were reports by women intense rivalry with other, often senior women, in their workplace, which included women resisting the promotion of their female co-workers. This was ascribed to the rival's motive to protect her hard won gains with male colleagues. It also prompts speculation as to whether, in order to succeed in a male dominated professional environment, women had to adapt, and assume, at least to some extent the perspectives, values and behaviours of the reigning male elite. Would such an 'adapted woman' resist, in the same way and for the same reasons as male associates, the professional advancement of other women?

The necessity for further studies as a prerequisite to advancement in SET is acknowledged by interviewees, but problematised. The combined responsibilities of a job, family and studies burden them with a workload that is difficult to sustain. Some interviewees reported reluctance from employers to sponsor or accommodate further study, perceiving women as a risky investment because they may leave to start families. Black women reported an additional challenge – the obligation to family that contributed to their initial studies now prevents them from taking leave of work and studying further.

Despite the difficulties, there are opportunities to progress in SET. Many interviewees were of the opinion that determination and an increasingly favorable work environment typified by diminishing gender bias and growing, even exclusive opportunities for women, predicted success for them in SET.

Networking and Teams

Including the themes: • Reluctance and difficulties in networking • Gender equality in networks and teams	"Women are also at a disadvantage when it gets to promotions. Because it starts out as an old boys club. They all went to varsity together – Just look at the top management – it is still male dominated."

For a number of reasons many women do experience difficulty in networking. These women believe they have to be cautious when interacting with male colleagues to avoid any hint of impropriety. Because there are fewer women in many areas of SET, networking is that much more difficult and women's networks suffer from neglect when they take time out to start families.

Many respondents mention an "old boys" network dominating their professional environments, the effect of which is exacerbated by the predominance of social events that are traditionally masculine, such as golf days. Because these factors limit their

informal interactions with fellow professionals, their ability to cultivate more rounded relationships with colleagues is undermined. Consequently, in order to benefit from promotion opportunities or be nominated to leadership positions, many women feel they have to be very assertive within their career setting because they cannot benefit from the networking building opportunities without.

Some interviewees indicated that there were no disadvantageous gender dynamics in teams. The view seemed to be that team formation is a tactic to address project imperatives, and is based on the availability of needed skills. Team formation is therefore rational, the flawed logic appeared to maintain, and the irrationality of gender discrimination is therefore avoided.

Sectoral Change and Emerging Issues

Including the themes:	*"Lots of men in the mining industry don't have the qualifications ... and if I say qualifications, I mean academic qualifications. They come through the ranks. Suddenly you get a post level that took him 20 years to get and the first thing that he says is that it's Affirmative Action and all that nonsense. Then I say: ok, if its AA then its fine because I was the best one they could get"*
• Affirmative Action • Female role models in SET • Gender independent issues • Being a black woman in SET	

Attitudes towards AA were predictably ambivalent. There was general agreement that women, but particularly black women, were positioned to take advantage of AA, and were indeed doing so. Some interviewees expressed dismay at having their career path undermined by AA, while a few others were concerned about the effect of AA appointments on quality of output. Many interviewees agreed that AA was a necessary intervention to address historical inequities that would otherwise continue to have an impact.

Interviewees repeatedly distinguished between the past and present day when speaking about female role models, and how the growing number of successful women in SET inspires success in new women entrants. However the concern reported earlier regarding the perceived imbalance between effort and reward was generally expressed when discussing the future of SET professions. Opportunities and remuneration were not regarded as commensurate with the sector requirements for professional advancement. Younger scientists also felt that there was an ageist creed that restrained their rapid progress, and some observed that the average age of SET workers seemed high and to be increasing. Some respondents further indicated that SET did not, on the whole, accommodate differently-abled workers.

A number of interviewees maintained that they continue to be discriminated against on the basis of race. Examples cited include skepticism from

"If you get more women in, you will find that they naturally progress. There is the danger that you want to promote them beyond their experience base. Everyone becomes uncomfortable. This approach does more harm to engineering in general and to women specifically."

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lecturers and employees concerning their competence; being passed over for promotion in favour of white, less qualified colleagues; exploitative salary arrangements; culturally biased selection processes; and language bias at university and in the workplace.

Table 1: Experience of Women in SET - Demographic Differences

The following table highlights differences in the occurrence of themes across relevant demographic variables, by ranking themes in descending order according to prevalence. The top three themes per demographic category are presented. Occasionally multiple themes share a top 3 ranking, in which case each is listed.

Gender		Level of Qualification			Work Context			Population Group	
Female	**Male**	**Bachelors**	**Masters**	**Doctorate**	**Academia**	**Industry**	**Science Councils**	**Black South Africans**	**White South Africans**
Men and other women as barriers to advancement (1)	Gender role education and conditioning (1)	Discrimination in the SET workplace (1)	Positive and negative experiences of gaining an SET related qualification (1)	Discrimination in the SET workplace (1)	Discrimination in the SET workplace (1)	Men and other women as barriers to advancement (1)	Discrimination in the SET workplace (1)	Discrimination in the SET workplace (1)	Discrimination in the SET workplace (1)
Discrimination in the SET workplace (2)	Discrimination in the SET workplace (2)	Men and other women as barriers to advancement (2)	Men and other women as barriers to advancement (2)	Men and other women as barriers to advancement (2)	Men and other women as barriers to advancement (2)	Discrimination in the SET workplace (2)	Men and other women as barriers to advancement (2)	Family versus a career in SET (2)	Affirmative Action (2)
Family versus a career in SET (3)	Affirmative Action (2)	Family versus a career in SET (3)	Family versus a career in SET (3)	Reluctance and difficulties in networking (3)	Gender independent issues (3)	Family versus a career in SET (2)	Gender independent issues (2)	Gender role education and conditioning (3)	Men and other women as barriers to advancement (2)
Affirmative Action (3)	Gender independent issues (3)	Further study as a barrier to advancement (3)	Further study as a barrier to advancement (3)	Affirmative Action (3)	Further study as a barrier to advancement (3)	Gender independent issues (3)	Affirmative Action (3)	Affirmative Action (3)	Further study as a barrier to advancement (3)
				Gender independent issues (3)					

Interventions for Women: Perceptions and Suggestions

The following section discusses the themes relevant to the research question *What are the perceptions of current and suggestions for additional interventions that may improve the representation of women in SET?* It explores the perceived flaws and limitations in current interventions designed to address gender discrimination, as well as reporting suggestions for improvements made by interviewees.

Current Interventions

Including the themes:	*"We've got something like more than 50 engineering societies and the biggest one is the institution of civil engineers, and 3 years ago already, its almost history now, they had a lady president, electrical had a president before that maybe 10 years ago, and the association of consulting engineers I think they have a lady president now. I think it's an indication of a big change."*
• SET as a non-discriminatory environment • Senior management representation • Preferential funding • Mentoring and role models • Special programmes and professional development • Recruitment and retention	

For some interviewees - women as often as men - discrimination constituted an explicit violation of a woman's basic human rights. A policy of barring women from accessing opportunities available to men would be an example of such explicit discrimination. However, habitually selecting men for a particular course of study would not, if the practice appeared incidental rather than intentional. No perception of tacit discrimination was expressed, let alone insight into the manner in which such tacit discrimination may be institutionalized. For these interviewees preferential policies or interventions favoring women were therefore unnecessary and merely bias in reverse.

Women who held this view were also likely to insist that a successful career in SET was predicated on individual ability and determination. Achievement meant out-competing men and women within the parameters of the status quo. Both men and women *"Well, I haven't heard my female colleagues complaining – there are no barriers. If you like engineering you will stay there."* interviewees who held this view were also likely to express the notion that their practice of science was gender blind and did not need to deliberately consider in its research programmes.

Most interviewees cited the growing representation of women in senior management positions as a positive indicator that the sector is transforming. The increasing frequency of women in leadership positions however, appeared to underscore the efficacy of equity policies rather than a general increase in the pool of women available in SET. Interviewees went on to discuss two points that serve to substantiate this interpretation. Firstly, prominent women are often professionally isolated from company of other females as they ascend the ranks into male dominated echelons. Secondly, especially in the commercial sphere, senior women are often called upon to perform a public relations function – to be the female face of their organization - in addition to fulfilling their regular responsibilities as scientists.

Interviewees could cite very few instances of interventions in SET specifically aimed at increasing the representation of women in the sector. Most of the programmes described included women in the broader category of the previously disadvantaged. When discussing access to preferential funding for example, interviewees were referring overwhelmingly to bursary schemes. Not only was there no mention of innovative preferential funding, but the bursaries usually favored previously disadvantaged individuals as a category, rather than women specifically. The trend extended into professional development initiatives and other special programmes. The majority of interventions mentioned were targeted at learners in high school or tertiary institutions, and although benefiting young women, were not gender exclusive. In academia, paid sabbaticals, the nurturing of a research culture and provisions for mentorship were cited as current interventions intended to increase the numbers of women in SET, but none of these made any differentiations on the basis of gender.

Gender rights may have benefited from being defined as a cross-cutting issue in policy formulation, in that it has at least become a routine consideration. But the dearth of gender specific interventions begs the question of whether it has not also suffered as a result of its cross-cutting designation. Gender representivity in SET is a critical issue, requiring focused rather than incidental redress. Its status as a rote consideration

> *"At the moment black men are favoured and women ignored. The company i worked for had seven black directors – they were technicians, people with BA qualifications, while there were women in the company with the right qualifications."*

however may well make it vulnerable to demotion behind more deliberate agendas.

Mentoring is considered an important intervention by many interviewees, of significant value at post-graduate and career entry level especially. The opinion that a lot more could be done with regards to mentorship programmes is widely shared. Interestingly, the professional stature and attentiveness of the mentor seemed more important to interviewees than the mentor's gender. In contrast, interviewees' conversation about role models for women appeared to implicitly and exclusively conceive of them as female.

Interviewees describing proactive initiatives of their institutions to increase the number of women employees were most likely to refer to recruitment, rather than retention strategies. When retention was discussed it was to reflect on the absence of any effective strategy and to emphasize the need for improving the institutions ability to hold on to its talent. Can it be inferred from these responses that the skilled female workforce in SET is mobile? There is certainly not enough evidence to suggest so. Female mobility was illustrated with anecdotes rather than trends and many women interviewees expressed reluctance to change jobs (usually because they felt they did not have the option to do so) – a clear challenge to claims of a mobility pattern. It is more likely that women interviewees, not wholly satisfied with conditions in the workplace, were pointing out that more energy is expended in getting them to sign up than to feel at home.

Feeling at home was attributed to a variety of employment practices, by far the most appreciatively and often cited of which were maternity leave benefits and flexi-time for working mothers.

> *"Child care facilities at work are a dream. Also, women being allowed to structure their time."*

Intervention Gaps and Blindspots

Including the themes:	*"No, I think it starts at school I think it starts before that I think that girls are brought up to be think science and maths is for boys."*
• Overlooking the obvious • Gender role education and conditioning • Social exclusivity, isolation and exploitation in the workplace • Dilution of preferential funding • Special programmes and professional development • The limits of policy intervention	

Interviewees emphasized that we cannot simply assume gains in gender equity are being consolidated. The obvious gender equity issues persist and must continue to be addressed. So, while institutions appear to conform at policy level, actual transformation meets with resistance and women continue to be discriminated against in the workplace; and while progress is made in the work environment, gender restrictions in the family or community may intrude on a woman's career. Many interviewees reiterated that gender role conditioning, especially in early education and career guidance, was a key determinant of career choice. The media was also seen by a number of interviewees as complicit in reinforcing stereotypes.

Interviewees indicated that while the number of women active in male dominated SET fields was on the rise, a male ethos in many instances remained. Consequently women continue to feel excluded, especially in the social sphere, which must be adeptly negotiated to access and secure career advancement opportunities. Exclusion is exacerbated for many senior women who, with few female peers, may begin to feel isolated. The theme of exploitation is also subtly introduced when senior women are presented as the 'female face' of an organization, and they are used to demonstrate the organisation's progressive gender equity practices. Starker examples of exploitation were introduce by a lesser number of interviewees, who believed that in some institutions, women received lower salaries than male colleagues and were assigned the less unpleasant or drudge tasks.

"I recently enquired about some jobs. One company offer relative peanuts. They offered me a job. In the interviews they asked me what my lowest pay was, and then they offered me 6 grand less. I though it was ridiculous. It was a top heavy female company. If they get a lot of women to work at this company, the industry must be offering females less else they wouldn't end up there."

Although there were a number of preferential funding initiatives underway considered beneficial to women, interviewees pointed out that they tended to targets a wider pool of previously disadvantaged individuals. The effect of such initiatives on promoting gender equity was thus diluted. The impression amongst these interviewees is that the objective is to fund quantity rather than quality, and by being so inclusive, incidentally furthering specific social agendas (like gender equity), exceptional individuals and promising research. A shotgun strategy for transformation however, requires bottomless funding reserves, a luxury the National System of Innovation does not enjoy.

Variations on the view that substantially more must be done to nurture the professional development of women in SET, through career guidance at school and university, mentoring in the workplace, special programmes and an organisation's career planning functions, were widely expressed. It seems that interviewees implicitly agreed that the professional development of women in SET needed systematic support at every step until such time as the increased representation made the entry, progress and achievements of women in the sector self-sustaining phenomena.

Although the need for policy interventions was acknowledged by most interviewees, a small number cautioned against over zealous advocacy of policy based solutions, arguing that career choices and life decisions are highly influenced by personal preferences and interests. The importance of personal preferences in choosing an SET discipline as a study direction and career was repeated widely across the

"I think if you really interested you'll make it to the top. You're making a decision about your future career based on having an affinity and talent. If you really are passionate about maths and engineering it's that passion that qualifies you."

sample and supports the policy skeptics to some extent. The presumption however, that personal preferences and interests are factors beyond policy, is not entirely accurate. Aptitude and preference are influenced by experience and policy that addresses the educational experience especially, seems poised, from the research evidence, to have a significant impact on the introduction of women into SET.

Proposed Interventions

Including the themes:
- No interventions are necessary
- Stimulating interest and approving attractiveness
- Improving access and opportunities
- Mandating and monitoring compliance
- Special programmes and professional development
- Accomodating special needs
- The Employment Equity Act

"The schools should do more to expose girls to science; it goes back to families as well. Girls should be supported to study sciences. It is everybody's effort and it should be addressed in a holistic way."

A few interviewees claimed that no interventions were required either because gender discrimination, in their experience, had been largely eliminated, or that success in SET was a function of personal attributes such as determination, ability, professionalism and competence. All that was necessary was to ensure that the same opportunities be extended to both men and women. For this group of interviewees there was no basis for claims of institutionalized, tacit gender discrimination in SET.

For most interviewees improving the influx of young candidates into SET was critically dependent on enhancing the attractiveness of the sector. A range of interventions for stimulating interest in and improving the attractiveness of a career in the SET sector were proposed. In terms of stimulating interest increasing exposure to SET information and activities, improving career guidance, bettering teaching facilities for science and technology subjects at school, and celebrating role models were mentioned. Suggestions

for increasing the attractiveness of the sector included higher salaries, better opportunities, accommodating women's family roles and celebrating achievements.

The suggestions for improving access and opportunities focused on increasing funding into SET from public and private sources; introducing more effective quota systems for studies selection, employment, grants and promotion; ensuring the availability of jobs in the sector, and even guaranteeing jobs for qualified women. Allied to this was the need for some form of professional development support. Suggested interventions in this regard included funding and facilitating continued education, mentoring, coaching in specific technical skills such as how to access research funding, facilitating networking, and comprehensive career planning and performance management.

> *"Give them more money. Make more space for women with families. Men are also becoming more involved in family. Mobile technology has freed us up and employees need to realise it. You can work any place any time. The perception that people have to be at the office needs to change."*

Many interviewees, both male and female, acknowledged that the multiple and contradictory role expectations women are subject to must be better provided for if their potential contribution to SET is to be fully realised. Proposed interventions associated with this theme emphasized accommodating women's domestic responsibilities by, for example, introducing flexible working hours, exploiting mobile technologies more thoroughly to facilitate flexi-time arrangements and offering on-site childcare facilities. A small number of interviewees however, challenged the automatic invocation of these obvious solutions, intimating that they bolstered a more elementary prejudice – the assumption that women are the primary homemakers and caregivers. Until this assumption was fundamentally altered, women would continue to suffer from the inevitable overload precipitated by the conflicting responsibilities of career and family.

A step towards reforming mindsets could be taken by employers extending the latter recommended concessions to both male and female employees, encouraging equity not only in the workplace, but on the domestic front as well. After all, gender bias in the workplace originates more generally in society's perceptions and expectations of women. Both men and women need reorienting in this regard. Besides the inventive proposal for employers, more conventional solutions such as educational interventions and mandating diversity on project teams were put forward.

Many interviewees considered the impact of the Employment Equity Act as positive in that it compelled employers to actively seek out equity candidates, raised awareness amongst PDIs of opportunities in the workplace, and precipitated transformation. These successes are undermined to some extent by resistance to transformation in a number of institutions and the slow appointment of women to more senior posts. To some extent these reservations are related to a more generally expressed dissatisfaction with the extent to which compliance with all existing policy interventions, not only the Employment Equity Act, is policed. For current and future policy to be transformative, monitoring and policing must become more robust.

> *"The policy of affirmative action forces society to change. But it has not done enough. Affirmative action has not been implemented correctly. They still don't think that if you have 200 people, 100 need to be women. During the whole struggle we were fighting together – now women have been left at the gate while everybody else has entered."*

A fair number of interviewees refuted the effectiveness of the Act, not just on the basis of non-compliance with the letter, but on the basis that the impact of its spirit has been limited. These interviewees would insist that true transformation has yet to take place and filling quotas was mere window dressing. Culture and ideologies remain unaffected.

Table 2: Interventions for Women - Demographic Differences

The following table highlights differences in the occurrence of themes across relevant demographic variables, by ranking themes in descending order according to prevalence. The top three themes per demographic category are presented. Occasionally multiple themes share a top 3 ranking, in which case each is listed with rankings indicated in parentheses.

Gender		Level of Qualification			Work Context			Population Group	
Female	**Male**	**Bachelors**	**Masters**	**Doctorate**	**Academia**	**Industry**	**Science Councils**	**Black South Africans**	**White South Africans**
Improving access and opportunities (1)	Employment practices(1)	Improving access and opportunities (1)	Improving access and opportunities (1)	Improving access and opportunities (1)	Improving access and opportunities (1)	Improving access and opportunities (1)	Gender role conditioning (1)	The failures of the employment equity act (1)	Improving access and opportunities (1)
The failures of the employment equity act (2)	Improving access and opportunities (2)	The failures of the employment equity act (2)	Gender role conditioning (1)	Mandating and monitoring compliance (2)	Mandating and monitoring compliance (2)	The failures of the employment equity act (2)	The failures of the employment equity act (2)	Mandating and monitoring compliance (2)	The failures of the employment equity act (2)
Accommodating women's special needs (3)	The failures of the employment equity act (2)	Employment practices (3)	The failures of the employment equity act (2)	The failures of the employment equity act (3)	The failures of the employment equity act (2)	The failures of the employment equity act (3)	Improving access and opportunities (3)	Accommodating women's special needs (3)	Mandating and monitoring compliance (3)
Mandating and monitoring compliance (3)	Gender role conditioning (3)		The successes of the employment equity act (3)		Employment practices (3)	Mandating and monitoring compliance (3)	Accommodating women's special needs (3)		Employment practices (3)
	Non-discrimination (3)		Mandating and monitoring compliance (3)						
			Supporting						

			professional development AND Senior management representation (3)					

Science for Women: Perceptions and Suggestions

The following section discusses the themes relevant to the research question *Why are so few scientific developments produced for women?* It considers the possible explanations for a marked absence of explicit gender perspectives in SET research output, as well as some suggestions for correcting this state of affairs.

Women are not specific beneficiaries of SET research output

Including the themes: • Research participants and agenda setters • Preferences, priorities and funding practices • Men as preferred research subjects	*"Certainly we have become more sensitive to the issue of women benefiting from the research and development, but essentially, a lot of it is at the very abstract level, with little consideration for what this might mean for actual people."*

By far the most prominent cluster of themes emerging from this section of the interview converged to assert that women do not specifically benefit from research output in the SET sector. There was little in the way of substantiation for this opinion i.e. very few illustrations were presented as evidence for the claim. This may have been because interviewers were the illustrators, presenting examples in order to explain the questions being put in this section of the interview. What was commonly offered as confirmation was the fact that respondents were aware of very few or no research projects explicitly considering differential benefits by gender. From this point the dialogue moved naturally from confirmation on the part of the respondent, to consideration of the reasons for this phenomenon.

One explanation was that the participation of women in active research and in setting research agendas was limited. Limited participation in turn, was presented as a consequence of historical and current gender bias in the workplace, and the lifestyle limitations inhibiting the career progress of women, especially in relation to family roles and responsibilities. An interesting aspect of the career limiting dynamics was that, in order to accommodate family responsibilities, as well as perceived gender specific limitations (e.g. "women are not suited to field work"), women tend to gravitate to tasks in practice that limit their progress later in their career. For example, instead of participating in field work, which may be time consuming and involve sacrificing family responsibilities, women may be compelled to choose alternatives such as computer modelling. Unfortunately in many arenas of SET, when it comes to assessing a scientist's credentials, it is field work that is valued more highly.

Another explanation was that the prevailing research preferences, priorities and funding practices did not favour gender explicit perspectives. The interest amongst scientists in gender as a research focus or significant component of their preferred research programmes is, in the opinion of many respondents, severely limited. Gender also features poorly in the current research priorities of the SET sector. This deficit is reflected in funding practices, where relatively little money is made available for research with

"Yes there is opportunity to do engendered research, but it is not the money puller. You need that kind of research from the big research institutions and big companies. But the money is not there."

substantial gender aspects. The interests of funders' also dictate, to a large extent, what research gets done. If funders consider gender superfluous to a research project, their influence may result in it being eliminated as a focus.

Lastly, a lack of deliberate consideration of the ultimate beneficiaries of research by scientists results in men becoming the default subjects of research. Consequently the benefits of research outputs are skewed in their favour. This is true of both outputs resulting from traditional experimental research, as well as more participatory methods where power relations and traditional gender roles also favour men as subjects.

Mainstreaming gender in SET research

Including the themes: • Awareness raising, education and support • Accommodating the roles, responsibilities and lifestyle imperatives of women • Mainstreaming gender through policy and practice interventions	*"I see no reason why we can't include gender as a parameter when awarding grants. We have criteria for black researchers. A special weighting for women in research is quite feasible. It is just as important as to ensure that you get innovative and cutting edge research."*

The second most prominent theme during this section of the interview consisted of respondents' recommendations as to how to ensure that women benefit more from research outputs in the SET sector. Recommendations emerged in three broad categories: awareness raising, education and support interventions; accommodating the roles, responsibilities and lifestyle imperatives of women; and mainstreaming gender through policy interventions.

Awareness of gender as an important consideration in research could be increased by deliberately exposing as many scientists as possible, both men and women, to appropriate research projects in their fields. The mechanisms for exposure were seldom clarified, but one suggestion included mandating participation in a gender sensitive research project for all scientists. The importance of considering gender should also be embedded in the education curriculae of scientists. Many respondents were also of the opinion that the more women practising as scientists, the more likely it was that gender issues would be mainstreamed. Consequently there were a number of recommendations for encouraging more women to study, qualify and seek work in the sector, including exposing young women to the career opportunities available, offering scholarships, and providing mentoring and support services to women who choose relevant study directions and careers.

"It is quite possible that if you have more female decision makers in the field that you could have a greater focus on issues important to women. If you look at the dismal representation of women at senior level, it is possible to imagine that this could have an impact. And you don't need many women, - One might be enough."

Based on the same premise as some recommendations from the previous theme – that the more practicing women scientists the more women's' issue would become mainstreamed in research outputs – a number of proposals for accommodating women's' special needs in the workplace were made. These included exploiting the possibilities technology offers for work flexibility and interventions that would assist women in taking care of family responsibilities, such as day-care facilities at work. Interestingly, a couple of respondents pointed out that such accommodations should not be exclusively targeted at women because they may entrench their marginalisation. Instead accommodations

should benefit both men and women thereby supporting the redefining of traditional gender roles.

Some respondents pointed out that there were very few if any specific compliance requirements in SET that would hasten the mainstreaming of gender in research and research outputs. Setting gender based quotas for research teams and mandating the articulation of possible gender issues in research proposals, as conditions for accessing funding, represent policy interventions that interviewees suggested would prove exceptionally effective. Policy interventions would have multiple beneficial consequences, including raising awareness of gender aspects of research outcomes and promoting the participation of women in core science activities, amongst others.

Gender sensitivity is unnecessary when setting research agendas

Including the themes: - Science is neutral - Gender issues have already been addressed - It's someone else's responsibility - It's not that important	*"How would you focus projects on women transport issues - there is no discrimination against women using the transport systems. We have roads, trains, buses, aeroplanes and anyone can use them. A lot of the research is gender blind."*

Next in prominence were a set of responses that disregard the significance of gender in the value of research outcomes. Perhaps predictably a number of interviewees were of the opinion that basic research, and their own discipline in particular, delivered gender neutral outputs. Some expressed this notion by claiming that research results benefited men and women equally. Others gave a more insightful response, recognising that the question was particularly relevant to research that culminates in results that are immediately useful in everyday life, such as product development. In most instances though, this was either to support the claim that their personal research was gender neutral, or in some way to pass responsibility for considering gender related issues to others further along the research value chain.

A number of respondents acknowledged the importance of considering gender but expressed the concern that this may at times be done at the expense of good science. The implication was perhaps that should empirical evidence demonstrate gender differences, these should be accepted despite possible controversy, or, in the case where research is gender neutral, resources should not be squandered pretending otherwise. In the same tone, but with less charity, a handful of responses betrayed impatience with gender as an issue.

Finally, while acknowledging that there may have been gender bias in research outputs in the past, it was no longer a problem in the present. Bias had been dealt with. Some cited the deliberate inclusion of gender as a sub- or cross-cutting issue in many research topics as illustrative of this claim.

Women are specific beneficiaries of gender sensitive SET research output

Including the themes: - Providing research output examples - Special arrangements	*"In some cases, like in the medical science women do benefit. Although again there is an argument that says that not enough of science output focuses on*

• Incidental beneficiaries • Downstream beneficiaries	*the health issues of women."*

Although not as abundant as claims that women do not benefit, the theme of women being specific beneficiaries of SET research did emerge from these interviews. Overwhelmingly, the theme consists of examples of these benefits, including specific examples from the respondents own field of research, but more often examples from other scientific disciplines. Specific examples were usually products (e.g. birth control), but also included examples from non-product related fields such as management sciences (e.g. gender differentiated employee health interventions). It was also pointed out that women benefited not just from the outputs of gender sensitive research, but also as recipients of funding to conduct the research.

Interviewees respond uncertainly to the concept of gender considerations in setting research agendas

Including the themes:
   • Uncertain responses
   • Gender bias in responses
	"I really haven't thought about it. I would have to say I can't think of anything specific."

A very intriguing set of responses was noted during the analysis, with a frequency and consistency that compelled attention and interpretation. It became clear from these common responses that for interviewees the concept of gender sensitivity in research was unusual and often difficult to grasp in their own context. Amongst other things this set of responses suggested forcefully that such an idea was unfamiliar with interviewees. It became apparent to interviewers that in many instances these questions were effecting an initial sensitisation amongst respondents to the possibility of gender considerations in their work. Indicative responses ranged from a complete and consistent misunderstanding of this section of the conversation, to repeated requests for clarification, admissions that the gender aspects of research had never occurred to them, evasiveness and a limited capacity to speculate on how gender might be relevant to their research context.

Every so often interviewees would reveal some personal gender bias. The bias could not characterised as outright prejudice, but tended to be more subtle or at worst paternalistic with a very few of the male respondents. Gender stereotypes like 'women are more empathic' would be invoked. Suggestions for research topics that benefit women would uncritically include 'kitchen and home products'. There was consistently an underlying implication that women should adapt to improve their lot, rather than attempt to redefine roles, responsibilities and expectations. For example, many respondents were proposing special accommodations for women in the workplace such as flexible working hours, while very few pointed out that such accommodations should be extended to men in order to raise the expectation that men begin sharing what is traditionally accepted to be 'the women's responsibility'. There were also suggestions that women, in order to maintain a career in science while meeting familial and other obligations, should withdraw from core functions like laboratory or fieldwork, and assume less demanding professional roles, such as support functions. While perhaps addressing lifestyle demands, the suggested solution still biases women by undermining their opportunities in science.

Table 3: Science for Women - Demographic Differences

The following table highlights differences in the occurrence of themes across relevant demographic variables, by ranking themes in descending order according to prevalence. The top three themes per demographic category are presented.

Gender		Level of Qualification			Work Context			Population Group	
Female	**Male**	**Bachelors**	**Masters**	**Doctorate**	**Academia**	**Industry**	**Science Councils**	**Black South Africans**	**White South Africans**
Women do NOT benefit	Gender not a concern	Women do NOT benefit	Women do NOT benefit	Gender not a concern	Gender not a concern	Women do NOT benefit	Women do NOT benefit	Women do NOT benefit	Women do NOT benefit
Mainstreaming gender	Mainstreaming gender	Mainstreaming gender	Gender not a concern	Mainstreaming gender	Mainstreaming gender	Mainstreaming gender	Gender not a concern	Mainstreaming gender	Gender not a concern
Gender not a concern	Women do NOT benefit	Gender not a concern	Mainstreaming gender	Women do NOT benefit	Women do NOT benefit	Gender not a concern	Mainstreaming gender	Uncertain responses	Uncertain responses

Conclusions and Recommendations

In the light of the summary findings and the interpretive discussion offered, what are the indications for intervention design and policy development if the described intentions are to be fulfilled? From the current research it is apparent that obstacles to participation by women in SET and to SET research output with an explicit gender perspective occur across society's institutions, and at every stage of the scientist's life cycle. A systemic approach to policy and intervention design is clearly required.

Furthermore, policy formulation needs to be strategic in the sense that government and DST by proxy need to exploit their position of advantage in implementing transformation. The White Paper on Science and Technology distinguishes between core and shared functions in the NSI, core functions being reserved for government. Policy should consider the collaborative implications necessitated by certain policy elements, and the unilateral opportunities inherent in others. A delicate balance must be struck between that which can be implemented with minimal consultation for quick gains, and that which requires stakeholder participation to ensure success.

A significant advantage favouring the transformation agenda of government is the fact that almost 30% of all research funding available in the NSI is under direct government control. This fact presents an exceptional opportunity to drive the recommendations made here.

Recommendations for interventions and policy are arranged thematically and essentially address institutional reform. Some recommendations overlap.

SET Community Interventions: Changing Minds

Policy often emphasises regulatory compliance, in itself a very effective approach, especially to secure quick gains. It is evident however, form the literature as well as the interview data that tacit bias embedded in institutional culture can continue to disadvantage certain groups. Values, world views and culture are more effectively address if civil rights policies are complemented by interventions with an emancipatory tone. The following recommendations are informed by such intent.

Sensitise the SET community to gender issues through a communications strategy

Ensure wide distribution of women in SET research results within and beyond the SET community. A communications strategy that relies on more than an ideological perspective but emphasises aspects such as the inefficient exploitation of valuable human capital implied by the facts, as well as the lucrative commercial opportunities when it comes to producing science for women, will enhance the information's transformative efficacy. Situating the information within national socio-economic objectives is also critical. It is important to speak to as many interest groupings as feasible.

Mainstream consideration of potential gender impacts in research projects and programmes where appropriate

As the interview data demonstrates, even women scientists are battling to understand the gender dimension of research agendas. While in some cases there is a legitimate claim to gender neutrality, often it is simply an entrenched habit of omission. Compelling a consideration of potential gender issues in research planning is an immediately imposable requirement at the intersection of public management and R&D, exploiting government's control of a third of the research funding available to the NSI. Public research institutions could integrate a formal, mandatory process into their research planning and publicly provided research funding offers a leveraging opportunity for requiring similar processes from private institutions. Cultivating the habit of engendered thinking will reveal its legitimate broader application to many scientists, encouraging a self-sustaining assimilation.

Compel meaningful female representation on large-scale research projects

As 10 years of affirmative action in South Africa has shown, compelling representation will prove successful to at least some extent. This may well have been the rationale informing the numerous proposals for such an intervention put forward by interviewees. Not only will representivity improve, but the inclusion of women researchers should contribute to the incorporation of gender sensitivity in the design and execution of research, even if only to a limited degree.

Entry Interventions: Growing Young Scientists

Research confirms the opinion of interviewees that the preference or indifference for a career in SET is cultivated early, in the home and at school. The following recommendations are proposed in recognition of this reality.

Devise a comprehensive strategy to address science anxiety

The extent to which science anxiety dissuades young learners from choosing a future in SET is significant. A multi-pronged, comprehensive strategy for addressing the challenge is necessary. The strategy could include:

- Additional research that will determine the correlation between factors such as quality of teaching, gender bias and science anxiety
- A review of interventions targeting science anxiety, and the implementation of interventions that have proven their efficacy
- Training educators to curb and mitigate the impact of science anxiety in the classroom

Mobilise the positive influence of parents

Parents emerge as especially influential in guiding the decisions of young women to what they should study and the career they should pursue, particularly, according to interview data, amongst black South Africans. It may be fair to suggest that young black women are also more likely to come from homes in which a traditional dispensation would include a "gender consistent" bias towards career choices that work against representivity in SET. Interventions targeting parents would inevitably include a communications

strategy through various media and participation in school activities. Emphasizing exceptional career opportunities on offer in SET, as well as dispelling the myths of gender suitability will erode the tacit and explicit bias diverting young women from education and career choices in SET.

Mobilise the positive influence of educators

Educators appear to be the influential equals of parents. This is fortunate in that educators are more easily accessed through policy and related interventions. Potentially they represent a key agent in the reform of SET. Literature and the current research suggest that policy targeting educators should include the following in its objectives:

Train educators to curb and mitigate the impact of tacit bias in the classroom

The impact of tacit bias has been demonstrated in research both at the secondary and tertiary education levels. Deliberate training of educators during their own tertiary years, and in continued professional development, to manage the prevalence and impact of tacit bias is critical.

Train educators to curb and mitigate the impact of science anxiety in the classroom

The impact of science anxiety on study and career choices should not be underestimated, nor should its exacerbating contribution to the factors already undermining young women's orientation to SET. Preparing educators to encounter and mitigate the effect of the phenomena may plausibly make a significant difference to enrolments and graduations in SET disciplines.

Prime and equip life orientation, as well as maths and science educators, to encourage further study in SET

Training for eradicating tacit bias and science anxiety in the classroom needs to be supplemented with resources for informing and guiding learner's study and career decisions. A lack of exposure to options in SET emerged as a potential factor dissuading learners from pursuing studies in that direction. Educators need to be sensitised to the strategic importance of graduating SET professionals to socio-economic development.

Resource maths and science educators to nurture performance in maths, science and technology studies

Identifying and nurturing high-achievers will help to combat attrition factors and keep young women in SET. Educators need methods, opportunities to inspire and incentivise performance (participation in Science Olympiads and prizes for achievement, special programmes for accelerated education and other innovations) and

equipment/facilities. Unfortunately the latter are often lacking in less privileged communities.

Interventions targeting young women learners

Expose young women to abundant career information and guidance on careers in SET

A very obvious gap as evidenced by the findings. Better information and guidance presents an opportunity for quick wins in improving more equitable gender representation in SET.

Ensure that all learners, including young women, have access to the appropriate education facilities

The contribution of lab work to enhancing understanding of science and academic performance is significant. Unfortunately such facilities, together with basic learning materials, text books and qualified educators remain critical challenges that need attention beyond the scope of the current policy research. Temporary innovative solutions can however be considered, modelled on initiatives such as the Gauteng Education Development Trust programme that encourages and funds joint improvement projects between well- and under-resourced schools.

Expose young women learners to SET environments and activities

Exposure to SET work environments emerged as an important factor encouraging especially those active in industry to pursue SET as a career. Young men are prioritised when opportunities to experience such environments arise. Programmes that deliberately expose young women to such environments need to be considered.

Provide gender specific incentives for performance in maths, science and technology

Currently the bursary and scholarship landscape is understandably concerned with racially based redress. The intervention is effective and should be used to address gender issues in SET. Creating scholarships, bursaries and prizes that target young women learners exclusively has enormous potential for increasing women's participation in the sector.

Celebrate women role models in SET

A number of interventions could be implemented in this regard. For example, inviting successful female tertiary science students to serve as ambassadors for the science, technology and engineering fields, having them visit high schools to inform high school learners about career options available in the SET field, as well as the challenges they might expect and how to overcome those challenges.

Mentoring and support programmes

Mentoring emerged as an important factor contributing to the academic and professional success of young women. Programmes that ensure high quality supervision of post-graduate women students will conceivably bolster equitable gender representivity in the sector. Supplementing the strained supervisory resources at universities by more systematic involvement of public institutions such as the CSIR is a possibility.

Sensitising lecturers of undergraduate students to tacit bias is also suggested. Support programmes that provide women students with access to peer groups may also prove valuable.

<u>Utilise learnerships more effectively</u>

Although not emerging directly from the research, there may be opportunity to better utilise the learnership programmes, in the light of findings regarding the role of mentors and peer group support. Some important innovations would include embedding the mentorship function into the learnership programme, and formally facilitating support groups.

Sector Interventions: Incentivising Science

Without a robust, competitive and rewarding research and development environment the hoped for socio-economic growth of South Africa is in jeopardy, and economic growth targets in excess of 6% are not realistically attainable. From the research a clear, definite need emerged to improve the input/reward ratio for SET professionals. The remuneration and supplementary benefits offered to especially newer career entrants in most fields is not perceived to be commensurate with the level of qualification, skill or work required.

The steady increase in R&D expenditure promises some relief in the future, as does the immanent growth in the local market for SET skills as the public works programme gets underway. It is by now self-evident but bears repeating that the development of skills to meet the demand, and the subsequent development of markets to absorb the skills, needs dedicated planning. DST has a limited influence over the broader economy but some immediate interventions for incentivising science may include:

- More and higher bursary and grant sums
- Significant monetary prizes for outstanding achievements in R&D
- Higher expenditure on salaries and benefits in state owned enterprises in the SET sector
- More deliberate government funded venture capital programmes for R&D, modeled on similar initiatives in other countries

Workplace Interventions: Valuing People

Investigate and implement best practice in accommodating women's lifestyle imperatives

There are two categories of concerns here. The first involves workplace and ergonomics. Many SET work environments remain female unfriendly. Equipment and facilities are designed with men in mind and women's participation is consequently, often severely limited. Issues such as these are often field specific – mining environments differ, for example, from construction. A public entity such as DST will need to play a leading advocacy and research role for these issues to be effectively addressed.

The second category involves family and child care. Literature consistently characterises establishing a family as enormously influential on women's careers. Its impact in the South African context was confirmed by the interview data. Interventions that help women reconcile family and career, such as flexible working hours or affordable, high

quality day care, will undoubtedly contribute to retention of female scientists. This is a notable opportunity for policy intervention.

Attend to employee retention strategies

The findings made it clear that little in the way of deliberate retention strategies have been implemented. There is a significant opportunity for intervention in this regard. Interviewee responses, corroborated by literature, seem to indicate a strategy based on professional development and support services, improving opportunities for career advancement, increasing financial reward in instances where the input/reward ratio is unsatisfactory, and accommodating lifestyle imperatives especially as concerns child care. Careful consideration of how to secure long-term participation from women scientists is likely to lead to addressing a broad range of gender representivity issues.

Design and implement professional support and development programmes

In workplaces that are often unaccommodating of women, support programmes should prove effective in retaining female scientists in the sector. The research indicates that interaction with women colleagues is highly valued, and mitigates the discomfort felt in a predominantly male culture, allowing women to integrate without having to adapt to male performance imperatives. Development programmes that facilitate further learning and advancement, while taking such factors as family obligations into consideration, should improve representation at all levels, but particularly in senior management.

Implement and engage women in systematic career path planning processes

A long-term plan for career advancement should incentivise career commitment, while simultaneously prompting the employer to correctly value its women scientists, accounting for the impact of future family obligations.

Funding interventions

Provide more preferential bursaries and scholarships that specifically target women

Most of the bursaries and scholarships available target PDIs generally, with little exclusively reserved for women. Specifying women as beneficiaries and SET fields as study options will immediately result in increased enrolments for the sector. There are many eager and capable young women who cannot afford to study that will choose SET, motivated by the incentive of funded studies.

Provide more preferential research grants favouring representation of women researchers on project teams

Mandating the representation of women on project teams as a condition for accessing research funding presents a policy implementation opportunity with quick gains potential.

Provide more preferential research grants favouring projects with outcomes for women

Very little exclusive funding exists for research projects that feature women as beneficiaries. Offering such funding will result in quick gains for increasing science output for women. Presenting interested researchers with a topic framework will also allow public funders to expand and direct the research for women agenda, which appears to need some enriching.

Effectively publicise the availability of preferential funding

If gender specific preferential funding is in place, there appears to be little awareness in the SET community. The process of accessing such funding must be fairly simple and clearly communicated, a necessity made clear by the documented experiences of public entities such as the Department of Trade and Industry.

Mainstream gender sensitivity by mandating the consideration of potential gender impacts as a basic funding condition

Mandating the consideration of potential gender differentiated impacts as a condition for funding is a reasonable and very effective policy intervention for not only increasing research output for women, but for sensitising scientists to the issue.

Policy Interventions: Formulating and Implementing Policy

Determine transformation priorities in SET in the light of public policy in order to devise an optimal advocacy strategy

Gender issues necessarily compete for attention and resources with other public policy priorities. There are also pressing transformation issues within the sector that need to be addressed, such as incentivising and growing the research and development environment, and improving remuneration trends. It is important to objectively review and strategically align gender issues with other key public research and SET transformation priorities, in order to devise the optimal advocacy strategy for making gains while serving the greater good – broad-based socio-economic development.

Investigate potential impacts of proposed policy through policy impact assessments

A substantial proportion of policy innovations founder due to insufficient consideration of the broader impacts of implementation. Careful planning in this regard will assist in garnering wide support for proposed policy reforms, as well as ensure that the effectiveness of interventions is optimised. A number of tried and tested methodologies for assessing policy impacts are available.

Develop transformation targets, monitor and publish progress

Momentum needs to be created and progress monitored through the development of monitoring tools, the setting of targets and the inclusion of stakeholders in the

transformation process. SAWinSETS is an example of a monitoring mechanism that could prove very effective. The final tool should be comprehensive, and comprehendible by a wide stakeholder base. A broad based buy-in of monitoring mechanisms such as SAWinSETS needs to be precipitated, probably through a well devised stakeholder engagement process.

Any policy compliance deficits must be noticeably and consequentially sanctioned

Unfortunately many compliance requirements imposed through transformation policy cannot yet be effectively policed. The research clearly demonstrates that where sanction is low, so is compliance. Any policy reforms must include penalties for non-compliance and the provision of resources for policing compliance.

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