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The role of self-efficacy in the careers of women in the field of Science, Technology, Engineering and Mathematics (STEM)

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Submitted in fulfilment of the requirements for the degree of

Philosophiae Doctor (Psychology)

In the Department of Psychology

Faculty of Humanities

UNIVERSITY OF PRETORIA

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April 2017

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Acknowledgements

I would like to acknowledge the following people for their contributions, which made it possible for me to complete this research:

- Dr Nicoleen Coetzee, my supervisor, for her guidance and professional contribution through this journey
- Ms Corlie van der Berg, my valued study friend, who constantly motivated me, shared difficulties with me and sent numerous messages of encouragement
- Prof Amanda du Preez, whose assistance with the finalisation of the manuscript was priceless
- Ms Rika Opper for her language expertise and editing
- Prof David Maree for all the statistical consultation and guidance regarding the quantitative data
- Ms Juanita Haug for her technical assistance
- All the women that availed themselves to take part in this study despite their incredibly busy schedules
- My colleagues on Floor 7 for their constant support, threats and encouragement
- David, Inandi and Maryke, who helped me along with tea, cookies, advice, words of encouragement and love. This belongs to you as much as it belongs to me!
- Everyone who walked this road with me
- The Almighty, who gave me this wonderful opportunity

Summary

This study was undertaken to investigate the role of self-efficacy in the career trajectories of women who are currently employed in STEM fields and women who had studied in any of these fields, but either never worked in STEM, or decided to leave at some stage. The assumption was that women remain in STEM careers because of the motivational effect of STEM self-efficacy. In order to do this investigation, two studies were included in a parallel convergent mixed-methods design and two samples were studied. The first sample of 15 women, which included both women in STEM (n = 8) and women who had left STEM (n = 7), were interviewed and invited to talk about their STEM studies and careers. The interviews were conducted according to a semi-structured interview. The second sample, which consisted of 108 participants of whom 88 were actively involved in STEM and 20 had left the field, completed an online survey that contained a biographical section, three self-efficacy scales and an Exploratory Questionnaire (EQ) that covered aspects such as motivation to study and work in STEM and barriers experienced. The three self-efficacy scales used were the General Self-Efficacy Scale (GSES), the New General Self-Efficacy Scale (NGSES) and the Occupational Self-Efficacy Scale (OSES).

Bandura's Social Cognitive Theory (SCT) was chosen as the conceptual framework for the study and the development of Social Cognitive Career Theory (SCCT) was described from its inception to its current integrated models of career development, as applied to women in STEM careers. The integrated models show that a combination of self-efficacy and outcome expectations is crucial as a predictor of career success in the STEM fields, which can also be influenced by additional variables, such as career decision making, career and study satisfaction, persistence, contextual support and barriers.

The Social Cognitive Theory (SCT) and Social Cognitive Career Theory (SCCT) provided the theoretical framework for themes for the qualitative thematic analysis. A top-down identification of themes was done by using the transcripts of interviews. Self-efficacy, outcome expectations and barriers were among the twelve themes that were identified. The survey data was described and statistically analysed. Descriptive statistics were provided for the self-efficacy scales and biographical information. The STEM and non-STEM groups were compared with a series of contingency tables on biographical information. A t-test was used to compare the self-efficacy scales by STEM status in order to find significant differences. The EQ was subjected to an exploratory principal component analysis (PCA) and 10 factors or components were identified. The factors ranged from motivation, barriers and perceptions

about gender to STEM and education. Finally, the factors were compared with the qualitative themes to explore the role of self-efficacy in the careers of STEM and non-STEM women.

The contribution made by this study is that it highlights the importance of the sources of self-efficacy in ensuring that women remain in their chosen fields. A frequently under-emphasised aspect is that of the emotional source of self-efficacy, which this study found to be the passion, focus, enjoyment and satisfaction that motivate women to remain in STEM. The relevant literature frequently observes that girls and women do not like STEM subjects and activities. However, the passion and commitment of women witnessed by the researcher while conducting this study counters this observation. Some women do enjoy science and it is by no means a proven fact that a lack of interest in STEM is gendered. Programmes focusing on motivating women to enter and remain in STEM ought to take this particular source of self-efficacy into account. The question is, of course, whether one can create interest, instil passion and make STEM attractive to women. However, this is a separate topic for further study.

One of the clear findings of this study relates to the importance of inner-circle support and motivation to enter and remain in STEM. Programmes should find a way to encourage families who are already involved in STEM to include children, and especially girls. The very personal nature of encouragement, motivation and support received from parents and close family members function as a major source of self-efficacy. This calls for a creative approach to motivational programmes in order to make commitment to STEM inclusive.

Another point that was emphasised by women in the qualitative sample, as well as in the quantitative results, was the major importance of personal interest in the field of science. In fact, this was even more important than the motivational support provided by close family. In essence, it relates to the passion expressed by women in STEM, but the importance of developing a strong interest in science cannot be overstated.

Finally, several of the respondents working either in or outside STEM mentioned the pressures experienced in an attempt to balance family and work responsibilities. Some women manage this successfully, even though they are in STEM careers, while others deal with the problem by leaving STEM. However, one should point out that even in non-STEM careers the pressures and expectations of family life and children exist. Programmes dealing with women in STEM should take this problem very seriously and should assist women in effectively managing and dealing with the combined pressures of family and work.

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Keywords

Agency

Career self-efficacy

Individual barriers

Outcomes expectancy

Reciprocal determinism

Science, Technology, Engineering and Mathematics (STEM)

Self-efficacy

Social cognitive theory

Structural barriers

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Statement of original authorship

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DECLARATION

Full name:	**Marinda Maree**
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Title of thesis:	**The role of self-efficacy in the careers of women in the field of Science, Technology, Engineering and Mathematics (STEM)**

I declare that this thesis is my own original work. Where secondary material is used, this has been carefully acknowledged and referenced in accordance with university requirements.

I understand what plagiarism is and am aware of university policy and implications in this regard.

M.Maree

SIGNATURE

31 March 2017
DATE

CHAPTER 1
INTRODUCTION

1.1 Introduction

This chapter sketches the background and context of the research and introduces the research problem, aims and methodology. It also includes an outline of the chapters of this thesis.

The focus of this research is the role of self-efficacy in the careers of women in the field of science, technology, engineering and technology (STEM). The under-representation of women in STEM careers is a recognised worldwide phenomenon and presents many challenges that have not yet been solved (Butler-Adam, 2015). Despite a number of initiatives and efforts to make STEM careers more accessible to women, the prevailing perception still is that these are careers for men (Thege, 2014). According to Morganson, Major, Streets, Litano, and Myers (2015, pp. 348-349),

> *A large percentage of qualified college students who begin their studies in STEM change to non-STEM majors before graduation … . Especially concerning are the gender disparities; girls and women are disproportionately lost along the educational pathway and are underrepresented in STEM majors and careers … . At the college level, research has considered a variety of factors to explain why students leave STEM and the associated gender differences in retention, including unwelcoming climates in STEM classrooms and departments …, lack of STEM-relevant interests …, low self-efficacy, and the influence of contextual supports and barriers.*

To date several factors have been identified that may function as barriers that make it difficult for women to study STEM, enter these fields and/or continue working in them. Some of these factors are lack of self-confidence, inadequate information about science careers, poor career opportunities, unequal salaries, lack of role models for women in science, not targeting women in hiring and recruitment practices, and the gender stereotypes that are emphasised in education and industry (Blickenstaff, 2005).

Numerous international and national campaigns and related initiatives to encourage female participation in the STEM fields have been implemented over the past two decades, and many organisations, governments, businesses and education institutions have been promoting the entry of girls into science. Attraction strategies were devised to encourage increased participation by girls, and retention strategies were initiated to keep young women in the education pipeline. The success of these strategies in reaching all girls is still seriously challenged by various factors, such as literacy levels, the rural location of many girls and the importance of maintaining the social and cultural structure of diverse communities where girls are located across the globe. The myths that science and mathematics are difficult and that girls cannot do science still prevails and is widely accepted (Bian, Leslie, & Cimpian, 2017; Blickenstaff, 2005).

1.2 Research problem

This study investigated the role of self-efficacy in women's science, technology, engineering and mathematics (STEM) career trajectories. Simply asking why women remain in this field if they have high levels of self-efficacy does not resolve the issue if one does not also ask the same question of women who had left STEM. How does self-efficacy function for women who entered STEM careers, but subsequently decide to leave? The purpose of this study was to determine the role of self-efficacy in either keeping women in STEM, or making them leave. The research problem could not be addressed by an experimental design. An experiment is not possible where levels of self-efficacy, what women study and where they work are manipulated. A design was required where the problem could be explored on more than one level, thus forming a tentative argument and arriving at an empirically informed conclusion. To determine the role of self-efficacy in two groups of women, one consisting of women in STEM and another consisting of women who had studied STEM but afterwards decided to leave the field, required a qualitative approach. It also required a way to describe the relationships between variables. This is called an interrogative approach, combined with a descriptive approach to investigate relationships.

1.3 Justification for the research

The reasons why women leave STEM careers have been thoroughly investigated and are well understood and recognised. However, the question arises why some women persevere in these careers despite having to deal with the same barriers that cause others to leave. This required an answer to the question: What are the attributes that make them stay? This study was an attempt to investigate the role of one of these attributes, namely self-efficacy, in assisting women to remain in STEM. Self-efficacy is one on the widely quoted attributes required by women and other minority groups to facilitate their entry into STEM and enable them to remain in their STEM careers. Furthermore, the question was posed that if self-efficacy does indeed play a role in people's decision to persevere, does it not also play a role in the decisions of others to leave STEM? The contribution made by this study can also be found in its secondary focus, namely to determine the role of self-efficacy in making women leave STEM. Answers to these questions would enable the development of strategies and inform programmes to motivate girls and women to enter and stay in STEM careers.

1.4 Research question, aim and objectives

The **research question** is: What is the role of self-efficacy in the different career trajectories of (a) women who remained in the STEM field for at least three years, and (b) women who trained for STEM careers but chose not to work in them, or who, after entering such careers, decided to leave the field for some or other reason?

The main **aim** of this study was to explore the role of self-efficacy in the career trajectories of women who studied in the STEM fields.

In order to achieve this, the following **objectives** were explored:

a. To examine the role of self-efficacy in women who have remained in STEM careers for at least three years
b. To investigate the role of self-efficacy of women who studied in STEM fields, but left their fields or made major career changes within the first three years after they had completed their studies
c. To determine whether, with regard to self-efficacy, women who have established careers in STEM differ significantly from those who made career changes.

1.5 Research background

It is important to understand the context of the issues addressed by this study. The general under-representation of women in STEM is a global phenomenon. The same tendency can be seen in sub-Saharan countries and in South Africa. According to the report *An assessment of the participation of women in STEM industry* (National Advisory Council on Innovation (NACI), 2008, pp. 13, 17) there is an increase in female students in higher education, but they remain under-represented in the STEM sector.

1.5.1 Under-representation of women in STEM

The lack of women in STEM, as also seen in sub-Saharan Africa, reflects issues more complex than merely having too few women in those fields. Amongst these issues are the impact of poverty, the lack of training and the legacy of apartheid.

A well-known metaphor used to explain the under-representation of women in STEM is the so-called "leaky pipeline" theory (Pell, 1996), which points out the crucial moments in a woman's career development and life milestones that could influence her decision to remain in, or exit her career (cf. the funnel model of Cronin & Roger, 1999). Thus it places the focus on the traditional difficulties faced by women, such as career breaks due to pregnancy and family responsibilities, work culture, such as surviving in a male-dominated environment and atmosphere, and women's expectations and the belief that science is not the appropriate field for them (Donovan, Hodgson, Scanlon, & Whitelegg, 2005). The crucial periods during which leakage can occur are during (a) early childhood; (b) adolescence; (c) entry to undergraduate studies; (d) the remaining part of graduate studies; and (e) the job entry time (Pell, 1996).

The reasons behind women's decisions to leave STEM careers have been extensively researched and discussed in the relevant literature (Blickenstaff, 2005; Etzkowitz, Kemelgor, & Uzzi, 2003; Godfrey-Genin, 2010; Pell, 1996; Rossiter, 1993) and focus on the barriers that cause the under-representation of women in STEM. Blickenstaff (2005, p. 372) mentions the following barriers:

a. Biological differences between men and women in terms of skills and ability prevent women from excelling in STEM.
b. Girls at school are not well prepared for a science career.
c. Girls have a negative attitude towards science and do not have positive experiences of science at school.
d. There are no role models in science for girls.
e. Science curricula do not apply to girls.
f. Pedagogical styles of science classes suit boys better than girls.
g. There is a "chilly climate" towards girls in science classes (Hall & Sandler, 1982);
h. Girls are expected to conform to traditional gender roles, which excludes STEM careers.
i. The worldview imbedded in science is masculine.

1.5.2 An explanatory conceptual framework: Social Cognitive Theory

Given the problem of women and STEM, the one barrier that gained importance over the years is women's lack of self-efficacy or, more precisely, STEM or career self-efficacy. Self-efficacy, which is defined as the belief that one has the capability to do certain things (Bandura, 1986), seems to play a significant role in enabling women to enter and persevere in STEM careers (Zeldin, Britner, & Pajares, 2008; Zeldin & Pajares, 2000). However, one of the questions this study sought to address was whether those who quit SET fields do so because of a lack of self-efficacy. This study will proceed from a Social Cognitive Theory perspective in order to determine whether self-efficacy is necessary and/or sufficient for SET career success.

Social Cognitive Theory (SCT) focuses on self-efficacy and the role of agency and outcome expectations in people's ability to direct and change their behaviour. It views people as being embedded within a social context, but also as people who are able to regulate their futures to a large extent. Behaviour is influenced by any number of internal and external factors and people do not merely react to an environment, but act and thus cause things to happen. The extent to which people believe they can change their own behaviour and environment depends largely on their levels of self-efficacy beliefs. Empirical research has shown that a number of achievements in various contexts depend on self-efficacy beliefs. In career development studies, the role of self-efficacy was incorporated in SCT from an early stage in its development. The main argument was that women seemed not to enter or remain in STEM fields, and that SCT might be able to illuminate the reason for this phenomenon. If careers that are not traditionally chosen by women require a special set of skills and perceptions, self-efficacy might be the crucial element allowing women to enter and remain in STEM fields (Bandura, 1986). Their success or failure will then depend on the levels of their self-efficacy beliefs and their ability to cope with and overcome obstacles and barriers.

Further developments in Social Cognitive Career Theory or SCCT became more sophisticated and examined more complex relationships between self-efficacy and outcomes, as well as the moderating and mediating role of various variables. So-called segmental models, i.e., models restricted to examining the self-efficacy-outcome relationship with one or more variables at a time, developed into integrated models. These models noted the influence of issues such as choice, interest, decision making, satisfaction and longitudinal performance. SCCT thus became a theory that incorporated development and major activities at different times during career development.

In this study two groups of women who had studied in STEM fields will be compared in order to investigate the assumption that self-efficacy is a necessary factor for a woman to be firmly established in a STEM career. One group will include women who have worked in the STEM field for at least three years. The second group will consist of women who had studied in the STEM field, but later made major career changes. While this implies that women with high self-efficacy might continue working in the STEM field, it also suggests that a lack self-efficacy could predict failure for the women who enter the STEM field. It might also mean that although women who decided to change their career paths might not have experienced high levels of self-efficacy in their STEM careers, but did so in their new careers. These different possibilities will be examined in the study and this is where its contribution to the field of psychology lies: it will provide a better understanding of the role of self-efficacy and how self-efficacy functions in different contexts and within the different career choices of women in science careers.

1.6 Research methodology

The interrogative and descriptive approaches to this study require engagement with women in STEM. It also requires an investigation of statistical relationships between self-efficacy and related variables. As mentioned above, by ruling out an experimental approach, access to the phenomenon requires a mixed-methods approach that incorporates both the interrogative and the descriptive approaches.

1.6.1 Research design

Since the need to engage with women to find out why they had made specific choices in their career trajectories necessitated interviews, a qualitative approach was chosen for this study. Furthermore, the study aimed at describing relationships between variables, which meant that levels of self-efficacy had to be determined along with women's perceptions of barriers and a host of very specific related issues. The approach to, and analysis of the latter required a quantitative approach. A mixed-methods design thus seemed to be the obvious choice. In this instance, by using both qualitative and quantitative approaches simultaneously, although not necessarily on the same samples, information could be gathered that answered the research question from different perspectives. A two-levelled study was decided on in order to facilitate triangulation. A parallel convergent design addressed these requirements (Creswell & Clark, 2011, p. 77).

In the parallel convergent design, the qualitative and quantitative strands are separated but run fairly concurrently. Qualitative and quantitative methods are used to collect and analyse the data. Samples generally differ in size, with the qualitative design using a small sample and the quantitative design a larger one to make it possible to address quantitative validity issues (Shadish, Cook, & Campbell, 2001).

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The purpose of a parallel convergent design is to compare data about the research under consideration that might differ (Creswell & Clark, 2011, p. 77). This design can combine the strengths of qualitative and quantitative techniques, such as combining the information obtained from a small qualitative sample with that obtained from a large quantitative sample in order to increase the validity of the conclusions drawn about a phenomenon. However, it can also be used to obtain multiple perspectives to increase our understanding of a phenomenon. Finally, should there be a convergence or divergence between the conclusions, data patterns or interpretation, understanding of the phenomenon and the context within which it operates or was studied can be clarified.

The principles of triangulation and complementarity facilitate the understanding of the research question (Creswell & Clark, 2011, p. 62). Triangulation seeks to merge the different methods for the purpose of validating inferences. The first principle of triangulation will be applied in the study as it views information from two different perspectives. Triangulation brings together the opposing strengths and non-overlapping weaknesses of quantitative methods with those of qualitative methods. The second principle of complementarity will be applied in this study by using quantitative and qualitative data collection methods in order to supplement inferences made from either one or the other (Creswell & Clark, 2011, p. 5). Complementarity seeks the explanation, improvement and interpretation of the results obtained by using one method with the results obtained by way of the other method. These two principles will guide the design on the levels of collection, analysis and interpretation of data.

One of the major requirements when using a combination of different designs and methods is to ensure that the eventual interpretation and understanding of the research question makes conceptual sense and does so coherently (Teddlie & Tashakkori, 2009, p. 286). An overall theoretical framework or conceptual framework that manages to integrate and facilitate an understanding and explanation of the phenomenon is crucial to the mixed-method approach.

1.6.2 Sample and data collection

Two samples were identified for this study. The qualitative sample consisted of eight STEM women and seven women who had studied STEM, but subsequently left the field. Interviews were conducted with this sample and the information obtained was transcribed.

The 88 STEM and 20 non-STEM women who constituted the quantitative sample completed an electronic survey. The purpose of the quantitative data collection process was to measure self-efficacy levels and to obtain information on women’s education and work experiences, and their perceptions of barriers encountered by women who studied in the STEM fields. A measurement instrument was developed for this purpose. This part of the survey can be called the Exploratory Questionnaire (EQ). The following three self-efficacy scales were included: the New General Self-efficacy Scale, the Occupational Self-efficacy Scale and the General Self-efficacy Scale. The three self-efficacy tests completed by the respondents will be described in terms of their psychometric properties and statistical characteristics. The questionnaire included a large number of items on barriers, motivation and STEM-related issues in education and work, which could be called contextual items

1.6.3 Data analysis

A thematic analysis was done for the qualitative data. Using the framework provided by Bandura's SCT and SCCT, the following 12 themes were identified:

a. Self-efficacy
b. Agency
c. Career decision making
d. Resilience
e. Outcomes expectancy
f. Family life
g. Work barriers
h. Sources of self-efficacy
i. Educational barriers
j. Personal barriers
k. Motivation to embark on STEM studies/ a STEM career
l. Leaving STEM

The quantitative analysis consisted of descriptive, inferential, data-reducing and modelling procedures. The sample was described in terms of biographical variables and differences between the STEM and non-STEM groups were determined by means of inferential methods. The main purpose was to determine whether there were significant differences in the self-efficacy scale scores of the STEM and non-STEM groups.

The EQ was subjected to an exploratory factor analysis or, more accurately, a principal component analysis (PCA). The following ten factors were determined:

a. External motivation
b. Internal motivation
c. External barriers
d. Organisational barriers
e. Education barriers
f. Balance barriers
g. Personal barriers
h. Ability perceptions
i. School perceptions
j. Gender perceptions

1.7 Chapter outline

This thesis is set out as follows:

Chapter 1. Introduction

General introduction to the research, including the research aim and objectives, the research question and the motivation for the research

Chapter 2. Literature review: Women in science, technology, engineering and mathematics

This chapter reviews the various fields in science, technology, engineering and mathematics (STEM), the representation of women in STEM in the international, sub-Saharan and South African contexts, and the barriers encountered by women in the STEM field. It also emphasises the impact of barriers on women's careers in the STEM field and the importance of female representation in STEM careers.

Chapter 3. Literature review: Social Cognitive Theory and career development.

This chapter focuses on the theoretical foundation of social cognitive theory. It includes a discussion on related terms, such as intentionality, forethought and self-reactiveness, a discussion of triadic reciprocal determination, and an overview of career development theories and Bandura's Social Cognitive Theory. It also contains a discussion of self-efficacy and the related terminology.

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Chapter 4. Research methodology

In this chapter, the research methodology used in this research is discussed, as well as the research design, the motivation for using the mixed- method approach, the characteristics of the samples, data collection and data analyses.

Chapter 5. Results – Qualitative

This chapter presents the empirical findings based on the qualitative data collected. It also contains a discussion of the thematic analysis, which is followed by the 12 identified themes and the chapter conclusion.

Chapter 6. Results – Quantitative

In this chapter, the empirical findings based on the quantitative data are discussed, as well as the data analysis, different self-efficacy scales, the exploratory questionnaire and the different methods applied for analysis.

Chapter 7. Discussion, recommendations and conclusion

This chapter focuses on the discussion of the qualitative and quantitative results and the researcher's recommendations for future studies. It ends with a final conclusion.

CHAPTER 2

LITERATURE REVIEW: WOMEN IN SCIENCE, TECHNOLOGY ENGINEERING AND MATHEMATICS

2.1 Introduction

In order to investigate the role women in Science, Engineering and Technology (SET) or Science, Technology, Engineering and Mathematics (STEM), a broad and fairly superficial overview of the STEM field will be presented in this chapter. The discussion does not purport to be an incisive analysis of the complex and intricate field of STEM, but is intended merely to serve to orientate readers with regard to where the study is located. It should be fairly obvious that we are not dealing with the social sciences or humanities, but with STEM. First, the different fields of STEM (the term STEM will be used throughout the study) are broadly defined. A discussion of the origins and growth of women's involvement in STEM in the international, sub-Saharan and South African contexts follows. It is important to realise that the problems experienced by women in the STEM milieu is not unique to South Africa, but is a long-standing and worldwide phenomenon. However, it is much more pronounced in Africa and Southern Africa, despite efforts by many institutions and bodies to encourage and increase the participation of women in the field of STEM.

Much of the basic work in terms of identifying barriers has been done and is applicable both internationally and locally. These barriers, which can be divided into two groups, i.e. structural barriers and individual or personal barriers, will be discussed to show how they impact on women's self-efficacy (to be investigated in the next chapter).

In the following section, the concepts and fields of science, engineering and technology are described.

2.2 Definitions of science, engineering and technology

The concepts used in the discussion of the STEM field need to be clarified in order to establish a common understanding of the constructs used in this study. A critical debating of the issues that define the field of STEM is beyond the scope of this study. Although the concepts of science, engineering and technology are described relatively uniformly in different countries, it seems as if the fields within each division are set out differently. For instance, posing the question about what engineering and technology is today, Godfrey-Genin (2010, pp. 541-542) laments the fact that even at the national level, for example in France, different views and classifications exist. It is therefore very difficult to present one classification system that will satisfy all the international views of fields and divisions.

The following section proposes one definition of science and the different fields of science.

2.2.1 Science

2.2.1.1 Definition of science

Science is a special process aimed at investigating reality. Reality can be explained as the world we live in and to which we have empirical access. Whitley (2002, p. 2) defines science as “a systematic process for generating knowledge about the world.” Although knowledge can be generated for its own sake, one can view the knowledge-generation process or the progression of scientific knowledge as being aimed at describing and explaining the world. The world is also generally viewed as consisting of what is natural, but due to human activity it also has social content. For instance, “Science,” (2008) describes natural science as “the study of nature and natural phenomena.” The term natural science is then used to distinguish the subject matter from the social sciences, which apply the scientific method to study human and social behaviour (Gilbert, 1991). The task of science is two-fold: descriptive and explanatory. According to “Science,” (2008), the task of descriptive science is “to develop a method of description or classification that will permit precision of reference to the subject matter.” Explanatory science focuses on the causal origins of phenomena (Bhaskar, 2008). This study refers specifically to natural science.

The aims of science are achieved through the so-called scientific method, and it is usually this method that distinguishes it from other human and/or social activities. When looking at different sciences, such as geography and physics, it ought to be clear that their methods differ greatly. For instance, while the advancement of knowledge in the field of physics is largely dependent on experimental methods, geography also employs other techniques to investigate phenomena. However, the values and principles of scientific investigation are common to all the approaches followed in the different fields of science. For instance, scientific knowledge can be distinguished from knowledge obtained through tradition, intuition and authority because its acquisition adheres to scientific values and principles. These principles include objectivity, openness and systematic, critical investigation (Bhaskar, 2008).

In the following section, the different fields of science are indicated.

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2.2.1.2 Fields of Science

One should ask what level of reduction ought to be used since taxonomies of science can be based on different principles. For instance, physics and chemistry seem to be more closely allied than physics and agriculture. Indeed, one can use the method of a particular science as basis for classification. For example, if the possibility of causal explanation exists, experimental sciences such as physics and chemistry can be grouped together. A field such as astronomy is not likely to make use of experimentation at all, and it is also not the main method for advancing knowledge in the geosciences. Some of the broad fields of science are defined below.

a. Agriculture: this discipline includes diverse fields, such as crop science (the study of the cultivation of crops), entomology (the study of insects), plant biology, plant pathology (the study of both organisms and environmental conditions that cause disease in plants) and soil science (the effect of soil and soil types and conditions on plant growth) (The American heritage science dictionary, 2005, p. 14).
b. Astronomy: "the scientific study of the universe and the objects in it, including stars, planets, nebulae and galaxies" (The American heritage science dictionary, 2005, p. 47).
c. Biology: the discipline or science of life includes a number of fields that examine phenomena related to living organisms and includes anatomy (the study of the functioning and structure of biological organisms), biochemistry (the chemical processes within biological organisms), biotechnology (the technological manipulation and production of biological phenomena), cell biology (the functioning of living cells), ecology (the study of the environment), genetics (the structure and function of genetic material), immunology (the study of immune systems), marine biology (underwater organisms), microbiology (the study of small-scale biological phenomena), molecular biology (the functioning of biological phenomena on a molecular level), parasitology (the structure and functioning of parasitic organisms and their hosts), photobiology (the interaction between biological organisms and non-ionising radiation) and physiology (the internal structure and function of organisms) ("Biology," 2012).
d. Chemistry: the scientific study of the structure, properties and reactions of the chemical elements and the compounds they form (The American heritage science dictionary, 2005, p. 116).
e. Computer science: the systematic study of computing systems and computation. Theories are developed for the understanding of computing systems and methods ("Computer science," 2012).

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f. Environmental science: this is the systematic exploration of the interactions between the physical, chemical and biological components of the environment, as well as the human impact on the environment ("Environmental science," 2012).
g. Earth science/Geoscience: this term refers to the sciences that focus on the earth, which include geology (the study of the development and structure of the earth), geophysics (the physics of the earth and its environment), meteorology (the study of phenomena in the earth's atmosphere) and soil sciences (the structure and function of soil) (The American heritage science dictionary, 2005, p. 190).
h. Information science: this science, which is also called informatics, lies close to computer science and information technology, but focuses on the study of information in relation to databases and software (The American heritage science dictionary, 2005).
i. Material science: this is the study of various materials, such as ceramics, artificial polymers and metals, and their applications in the fields of chemistry, physics and engineering ("Material science," 2012).
j. Mathematics: the mathematical sciences include a number of related fields dealing with numbers, space and quantity ("Mathematics," 2012).
k. Neuroscience: this field of study deals with the structure, function and development of the nervous system. It includes genetics, biochemistry, physiology, pharmacology, and pathology of the nervous system ("Neuroscience," 2012).
l. Physics: this is regarded as a fundamental science because it studies the basic constituents of the universe and basic forces and interactions that apply to the known universe (The American heritage science dictionary, 2005).
m. Oceanography: the scientific study of oceans, the life forms that inhabit them, and their physical characteristics (The American heritage science dictionary, 2005, p. 439).

Engineering is one of the core fields in the STEM sciences. It is essential to have a broad understanding on how engineering differs from the field of other sciences. The core concepts in the field of engineering are discussed next.

2.2.2 Engineering

While the natural sciences rely on empirical tests to obtain evidence for hypotheses, engineering is the application of science (Wyer, Barbercheck, Ozturk, & Wayne, 2009, p. 8). The definition and a discussion of the fields of engineering follow below.

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2.2.2.1 Definition of engineering

An older definition of engineering comes from Fletcher and Shoup (1978, p. 5): “Engineering is the systematic and scientific application of knowledge aimed at the application of scientific principles to create useful processes.”

The following two definitions expand on the above:

a. Engineering is the “(A)pplication of scientific principles for practical purposes …” Engineering fields include mechanical, civil, chemical, electrical, aerospace, industrial and nuclear engineering ("Engineering," 2012).
b. Engineering is “(T)he application of science to the design, creation, and function of machines and structures” ("Engineering," 2007; "Engineering," 2012).

2.2.2.2 Different fields of engineering

The broad fields of engineering are:

a. Aerospace or aeronautical engineering: focuses on the design, development and operation of vehicles and equipment used in the earth’s atmosphere and beyond (Fletcher & Shoup, 1978; "Technology," 2000).
b. Civil engineering: is concerned with engineering applications aimed at civil society, such as the designing and construction of buildings, water supply and transport, and in general with improving the quality of life. Civil engineering has a number of subdisciplines, such as geotechnical engineering, construction engineering, structural engineering, environmental engineering, water resource engineering, transportation engineering and pipeline engineering ("Civil engineering," 2008).
c. Chemical engineering: deals with the practical application of chemical processes in the development and modification of materials and products (Fletcher & Shoup, 1978, p. 12). It involves the “research, design, improvement, operation, and commercialization of plants, processes, and products for the chemical industry and related fields, such as biotechnology, energy, and materials” ("Metallurgy," 2008). Nuclear chemical engineering is the branch of chemical engineering that deals with nuclear power generation ("Nuclear chemical engineering," 2008).
d. Electrical engineering: the branch of engineering that deals with electrical systems and their applications. It is concerned with delivering power to industry and residential areas ("Electrical engineering," 2008).

e. Electronic engineering: can be regarded as a branch of electrical engineering and deals with small-scale electronic systems and components ("History of technology," 2012).
f. Industrial engineering: focuses on the “development, design and maintenance of industrial operations” ("Industrial engineering," 2004).
g. Mechanical engineering: deals with the conceptualisation, design, construction and operation of machinery (Fletcher & Shoup, 1978, p. 5; "Mechanical engineering," 2008).
h. Metallurgical engineering: the branch of engineering that focuses on the production, application and maintenance of metals ("Metallurgy," 2008).
i. Nuclear engineering: focuses on the production and application of nuclear energy and radiation. Nuclear engineers design, develop, monitor and operate nuclear plants used to generate power ("Nuclear engineering," 2008).
j. Marine engineering: concerned with the design, production and application of marine vehicles, systems, machinery and ships ("Marine engineering," 2008).
k. Software engineering: concerned with developing and maintaining software systems (Frakes, 2008).
l. System engineering: an interdisciplinary field of engineering that focuses on applying knowledge to improve the operation of organisational units. It is based on the natural sciences, but works with information and knowledge as applied to human functioning in organisational units. It is mainly a “management technology” and the “purpose of systems engineering is to support organizations that desire improved performance” ("Systems engineering," 2008).

2.2.3 Technology

Science and engineering, which were discussed in the previous section, can be briefly defined as the description of the empirical reality, while engineering involves the application of science. The following discussion will focus on technology and will explain how this field of study differs from those of science and engineering.

2.2.3.1 Definition of Technology

According to various descriptions, technology and engineering are almost similar activities since technology also requires empirical experiments and tests in order to deliver working products and effective results (Wyer et al., 2009, p. 8). However, it differs largely from science and engineering in terms of providing artefacts to satisfy real and practical needs (Wyer et al., 2009, p. 9). Technology is also seen as “… the application of scientific knowledge to the practical aims of human life or, as it is sometimes phrased, to the change and manipulation of the human environment" ("Technology," 2000). Various sources define technology as the practical application of scientific knowledge (*The American heritage science dictionary*, 2005; "Systems engineering," 2008; "Technology," 2000; "Technology," 2008b).

Although the aim of this study is not to explain the difference between science, engineering and technology, an attempt will be made to distinguish between the different areas. Both technology and engineering are concerned with the practical application of knowledge. The main difference between science and technology is that the former focuses on the systematic investigation of knowledge, whereas the latter is concerned with fabricating objects and tools that are useful to human beings ("History of technology," 2012). The difference between engineering and technology is probably located mainly in their relationship to scientific knowledge. Technology is an older form of social practice than science and did not initially depend explicitly on utilising scientific knowledge – a relationship that only developed later in modern and westernised versions of technology. Some authors actually maintain that from the 17th century, technology and engineering could be regarded as the same thing ("Technology," 2000).

Technology is thus the practical consequence of scientific knowledge and principles. It is responsible for practical techniques to solve real and practical problems. During this process of solving problems it also creates tools. Engineering is closer to science in that it provides a systematic framework for knowledge, but it is also close to technology as it makes this knowledge available for practical purposes. One could therefore say that "technology is responsible for making the tools to carry out the engineer's plans" ("Technology," 2008a). Grübler (1998, p. 19) describes technology as dynamic as it is continuously changing for the better, or rather its development is progressive towards always more effective practical solutions.

2.2.3.2 Fields of technology

The fields of technology include the following:

a. Agricultural technology: uses "Application of techniques to control the growth and harvesting of animal and vegetable products" ("Agricultural technology," 2012).
b. Biotechnology: uses or exploits biological systems for industrial and related purposes, for instance the genetic engineering of plants and replacing body parts ("Biotechnology," 2010).
c. Construction technology: focuses on the construction of buildings and other structures. It involves three areas, namely data technology, materials and equipment. For

instance, data technology enables the design and visualisation of complex structures while material and equipment technologies facilitate the effective construction process ("Emerging construction technology," 2008).

d. Environmental technology: concerns with land, air and water in interaction with biological, chemical and physical phenomena. It is also concerned with managing the use and reuse of these systems (such as water use and recycling) (Corbitt, 2008). Environmental technology is thus focused on utilising technology to fulfil the aims of use and reuse. A more specific definition is: "Any technology that is designed to control pollution, treat or store waste materials, or clean up contaminated sites" ("Environmental technology," 2007).
e. Geographic information systems (GIS): utilises "A computer system that is designed for the storage, manipulation, analysis, and display of large volumes of spatial data in a map format" ("Geographical information systems," 2007). Although a distinction is usually made between a field of study and a technological application, GIS can be both.
f. Information technology (IT): is also regarded as a field of engineering. It deals with computer hardware and software used for information storage, analysis and the transmission and manipulation of data ("Information technology," 2008).
g. Manufacturing technology: creates computers, semiconductors and their parts to the building of state-of-the-art equipment, machines and production system ("Manufacturing," 2012).
h. Nanotechnology: refers to "(T)he development and use of devices that have a size of only a few nanometres." Nanotechnology involves subatomic particles that act in certain ways and because they are so small, operations can be done much quicker than when larger components are involved. Molecule structures are then fashioned into small devices that do the work (Daintith, 2009).
i. Transportation technology: refers to the development and use of technologies that enable people to move themselves or goods more quickly from one point to another. Bicycles, cars, trains and aeroplanes are examples of transportation technology ("Transportation technologies," 2005).

2.2.4 The relationship between science, engineering and technology (and mathematics)

The relationship between these three fields can be conceptualised as follows: Science is aimed at discovering the principles of nature, engineering applies these principles and technology builds the applications. However, the distinction between the three domains is not always that apparent. For instance, as mentioned above, science has an explanatory and taxonomic task which it achieves through the scientific method (which, as mentioned earlier, comprises of a collection of methods that adhere to specific values and principles).

Technology is governed by principles such as utility or practical value, which is not the main aim of science, and engineering “exploits” natural phenomena, but the techniques used for this purpose are not always based on science. It is clearly not easy to model the relationship between science, technology and engineering. Historically technology developed before science and engineering, but technology usually flows from science and engineering. It should probably be seen as a reciprocal process between the three domains, where science sometimes develops the knowledge applied to produce mechanisms that can be utilised in engineering and technology. However, technology also provides the instruments used by scientists for their investigations.

Mathematics is a core discipline that underlies almost all the fields in STEM. It is not really necessary to define mathematics and its various fields, and it will suffice to say that it is the one common denominator in all fields of STEM.

In this study, any reference to STEM will imply the definitions and descriptions provided above, and references to STEM/SET will include industrial, academic, scholarly and research activities in the scientific domain as described above. For the purpose of this study, and without denying their scientific status, the social sciences, arts and humanities will not be included in any references to science in this thesis. Other acronyms are also used in the literature to refer to the conglomerate of disciplines jointly referred to here as STEM, i.e., science, technology, engineering and mathematics (Chen & Weko, 2009, p. 2; Kokkelenberg & Sinha, 2010, p. 936). Although the use of other acronyms is also acceptable, one can assume that they all refer to the natural sciences and associated fields. STEM will be used in this study.

2.2.5 The areas and fields of science

In this section the different areas and fields of science and engineering will be briefly discussed. Chen and Weko (2009, p. 24) divided the fields of science into six broad areas:

a. Mathematics
b. Natural sciences
c. Physical sciences
d. Biological/ agricultural sciences

e. Computer/ information sciences
f. Engineering/ engineering technologies

It is interesting to note that Chen and Weko (2009, p. 24) include engineering as a category of science. Other sources usually refer to engineering as a separate area. The above categorisation by Chen and Weko (2009, p. 5) broadly reflects the STEM divisions in higher education institutions in South Africa. The academic science yearbooks of the five top local universities (based to student numbers), i.e. the Universities of Cape Town, Pretoria and the Witwatersrand, and Rhodes University, were examined to determine the areas of science and fields of specialisation utilised in the South African higher educational environment. ("Top universities, colleges in South Africa 2012," 2012). These universities' categorisations of Science, Engineering and Technology are summarised in Table 1.

Table 1 Engineering and science fields at five top South African universities

University	Engineering fields (Application)	Natural Science (Fundamentals)
University of Cape Town	Chemical Engineering Civil Engineering Construction Economics and Management Electrical Engineering Mechanical Engineering	Archaeology Astronomy Botany Chemistry Computer Science Environmental and Geographical Science Geological Sciences Mathematics and Applied Mathematics Molecular and Cell Biology Oceanography Physics Statistical Sciences Zoology
University of Pretoria	Civil Engineering Industrial and Systems Engineering Chemical Engineering Electrical, Electronic and Computer Engineering Mechanical and Aeronautical Engineering Material Science and Metallurgical Engineering Mining Engineering	Biochemistry Biological Sciences Biotechnology Ecology Entomology Genetics Human Genetics Human Physiology Human Physiology, Genetics and Psychology Medical Sciences Microbiology Plant Pathology Plant Science Veterinary Biology Zoology
Rhodes University		Physical Sciences, including Chemistry and Physics Information Sciences, including Computer Science and Information Systems Earth and Environmental Sciences Life Sciences Mathematical Sciences

University	Engineering fields (Application)	Natural Science (Fundamentals)
		Human Sciences Unspecified classification including Physics and Electronics
Stellenbosch University	Chemical Engineering (including Mineral Processing) Civil Engineering Electrical and Electronic Engineering Industrial Engineering Mechanical Engineering Mechatronic Engineering	Physical Sciences Biological Sciences Programmes in the Mathematical Sciences Agricultural Sciences
University of the Witwatersrand	Architecture and Planning Chemical and Metallurgical Engineering Civil and Environmental Engineering Construction Economics and Management Electrical and Information Engineering Mechanical, Industrial and Aeronautical Engineering Mining Engineering	Biological and Life Sciences Animal, Plant and Environmental Sciences Molecular and Cell Biology Physics Chemistry Earth Sciences Geography, Archaeology and Environmental Studies Geosciences Mathematical Sciences

The six fields suggested by Chen and Weko (2009, p. 24) were used as the broad areas of science and engineering for the classification of the five top universities' fields of specialisation in . The overlapping fields were discarded and the results are shown in Table 2. Technology is not included in this table since it is viewed as the application of the various areas and fields.

Table 2 Areas and fields of science and engineering

Area of science	Specialisation fields
Mathematics	Mathematics, Applied Mathematics and Statistical Sciences
Natural sciences	Earth sciences, Ecology Entomology Environmental Genetics Geographical Science Geological Sciences Physiology Microbiology, Molecular and Cell Biology Oceanography Zoology Archaeology
Physical sciences	Chemistry, Biochemistry Astronomy Physics
Biological/agricultural sciences	Agricultural Sciences Animal, Plant and Environmental Sciences Biological Sciences, Biotechnology, Botany, Plant Pathology, Plant Science

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Area of science	Specialisation fields
Biological/agricultural sciences	Agricultural Sciences Animal, Plant and Environmental Sciences Biological Sciences, Biotechnology, Botany, Plant Pathology, Plant Science
Computer/information sciences	Computer Science, Information Sciences – including Computer Science and Information Systems
Engineering/ engineering technologies	Aeronautical engineering Architecture and Planning Chemical Engineering Civil Engineering Civil Engineering Construction Economics and Management Electrical and Electronic Engineering Environmental Engineering Industrial and Systems Engineering Mechanical Engineering Mechatronic Engineering Metallurgical Engineering Mining Engineering

The representation of women in STEM will be discussed in the next section.

2.3 International representation of women in STEM

Women have been trying to gain access to the various fields of STEM for more than a hundred years (Caprile et al., 2012; *Women for science: An advisory report*, 2006, p. xviii). Guterl (2014, October 1) mentions that women in the United States struggled to participate in science ("Women in science," 2015; Wyer et al., 2009, p. 15). This struggle was complicated by debates about women's intellectual capability. Although some progress has been made, much still needs to be done to promote women's participation in science (European Commission, 2012). Hill, Corbett, and St. Rose (2010, p. 2) mention the remarkable advances made over the past 50 years, but also state that a final victory cannot yet be claimed (Caprile et al., 2012). The situation is aptly summarised on p. ix of the 2006 report titled Women for science: An advisory report:

> *While women constitute half of humanity, even in countries where they have ready access to higher education, the number of women studying mathematics, physical science and engineering remains drastically below parity with men. Talented and capable women are essentially turned away from these and other fields, and the few who persist typically find themselves isolated and marginalized.*

According to Walters and McNeely (2010, p. 317) and a report by Boshoff (2015), the global innovation-driven economy is pressurising STEM fields to become more competitive and sustainable. Chen and Weko (2009, p. 1) state that concerns about the USA's ability to sustain global economic competiveness are causing renewed interest in STEM fields. Power (2012, p. 40) supports this statement when he points out that sexism in the Middle East is causing severe damage to the economy. According to Power (2012), only 25% of all employees in the Middle East and North Africa are women, and their contributions are in fact essential for growth and economic stability.

Both the synthesis of the EU Report (Caprile et al., 2012) and White (2010, p. 79) noted that research in various countries, such as the United States of America, Canada, India, Japan and certain European countries, has shown that women are not sufficiently represented in STEM careers. For example, in the USA, women are represented in only 32% of STEM occupations. Furthermore, Goodrich (2016, November 7) indicates that only 8% of the UK workforce are employed in STEM professions (Hill et al., 2010, p. 2), which implies that the economy, productivity and innovation rely on only a small segment of the workforce. Furthermore, women constitute only a tiny fraction of this relatively small segment. A diverse workforce has the benefit that products and services are better designed and can be utilised by a broader base of consumers (Caprile et al., 2012; Hill et al., 2010, p. 3). According to Hill et al. (2010), a sufficient number of women is required in the STEM fields to ensure innovation, creativity and competitiveness. One reason for this is that product design often does not take the needs of women into account. An example of this is the development of the calibration of earlier voice-recognition systems using male voices. Hill et al. (2010, p. 3) point out that if technological products are designed by a variety of individuals, they will be more likely to satisfy the needs of diverse consumers.

Although several studies have shown an increase in the numbers of women in science, research and management, those studies also indicated that the change is slow and not sufficient (Caprile et al., 2012; Kassabian & Nedden, 2014; Lipinsky, 2014). In the report titled *Women, research and universities: excellence without gender bias*, Maes, Gvozdanovic, Buitendijk, Hallberg, and Mantilleri (2012, p. 3) comment that "*while progress has been made, and is being made, in reducing gender inequality, change may come about slowly and is subject to significant variation according to country, research field and other fact*ors" (Caprile et al., 2012).

According to *She Figures 2012* (Maes et al., 2012), there has been a significant increase in the number of women receiving tertiary education, and in some countries female students are the in the majority. In Canada, for instance, they constitute 55% of all students. This tendency can also be seen in other European Union countries where up to 67 % of students are women

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(Maes et al., 2012; Rees, 2010, p. 23). According the UN report, *The world's women 2010* (Mrkic, Johnson, & Rose, 2010, p. 35), the number of people receiving tertiary education worldwide more than doubled from 66.9 million to 152.4 million between 1990 and 2007. The remarkable fact about this increase is that female students are now in the majority. In 1990, male enrolments comprised 54% of total enrolments; by 2007, female enrolments had increased to 51% (Boshoff, 2015; Mrkic et al., 2010, p. 62). The report by the European Foundation for the Improvement of Living and Working Conditions (2008, p. 9) points out that the increase in women in tertiary education does not imply an increase in the number of women in STEM fields. Therefore, despite the overall growth in the number of women in tertiary education, they are still underrepresented in STEM fields and best represented in the social sciences (Boshoff, 2015; genSET, 2011, p. 15).

Even where an increase in the number of women in STEM study fields was noticed, it did not necessarily lead to more women in STEM-related occupations. The reason for this is that the dropout rate for women in these study fields was higher than that for men. The genSET report provides the most recent information about women in STEM (genSET, 2011). According to this report, significant inequality with regard to the number, seniority and impact of women in STEM fields still persists in Europe. The report emphasises the continued reference to concepts such as the glass ceiling, the sticky floor and the leaky pipeline to explain the underrepresentation of women in STEM. In reality, STEM fields still have to deal with the consequent significant loss of talent, innovation and intellectual capacity (Boshoff, 2015).

According to the report titled "Why so Few Women in Science, Technology, Engineering and Mathematics?", equal numbers of boys and girls enrol for maths and science (Hill et al., 2010, p. xiv). Furthermore, both genders are initially eager to pursue a career in science and engineering, but more young women than men lose their interest in a STEM career during the first year of study. By the time they graduate, men outnumber women in almost every field of science and engineering. In a recent article Goodrich (2016, November 7) mentions that, according to the latest UK Office for National Statistics figures, only 8% of engineers in the UK are women, despite constant efforts to increase the representation of women in the STEM fields.

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A further loss of women is evident when they enter the workplace. Etzkowitz et al. (2003, p. 1) recounted the story of the scientist Leslie Barber[1], who ended her career as a molecular biologist shortly after receiving her PhD degree. Barber had evaluated ten graduates (five men and five women) in her research group and found a clear difference between the career trajectories of men and women. The men had continued to pursue their careers forcefully as scientists, regardless of their achievements or lack thereof. Three of the women exited from their research careers, while the remaining two regularly experienced gender bias in their postdoctoral positions. After exploring the women's stories, Barber came to the conclusion that the traditional pattern of exclusion of women in science professions is still very real and alive. Despite recent advances, it appears that women still need to overcome several gender and other related barriers (Etzkowitz et al., 2003, p. 2; Shen, 2013).

Despite the increase in the numbers of women in tertiary education (Hill et al., 2010, p. 14) and the constantly growing number of women enrolling for tertiary training in STEM fields, women are still not represented in adequate numbers (Shen, 2013). Ja Shin (2012, p. 30) found the same tendency, namely that more women studying at a tertiary level does not result in more women in the worker corps (Guterl, 2014, October 1). Munn (2012, p. 130) agrees with this finding and adds that 70% of female STEM graduates do not enter their professional fields. Hill et al.'s (2010, p. 14) breakdown of women in the various STEM fields can be seen in Figure 1. The statistics were sourced from the US Department of Labor, Bureau of Labor Statistics (2009) (Hill et al., 2010)[2].

[1] Leslie Barber is a molecular biologist. She decided to end her career as a research scientist shortly after being awarded her doctoral degree. She reflected upon the mixed experience of her male and female peers.

[2] Estimates of the size of the scientific, engineering and technology workforce provided by several US government agencies, including the Census Bureau, the National Science Foundation and the Bureau of Labor Statistics, after using different criteria.

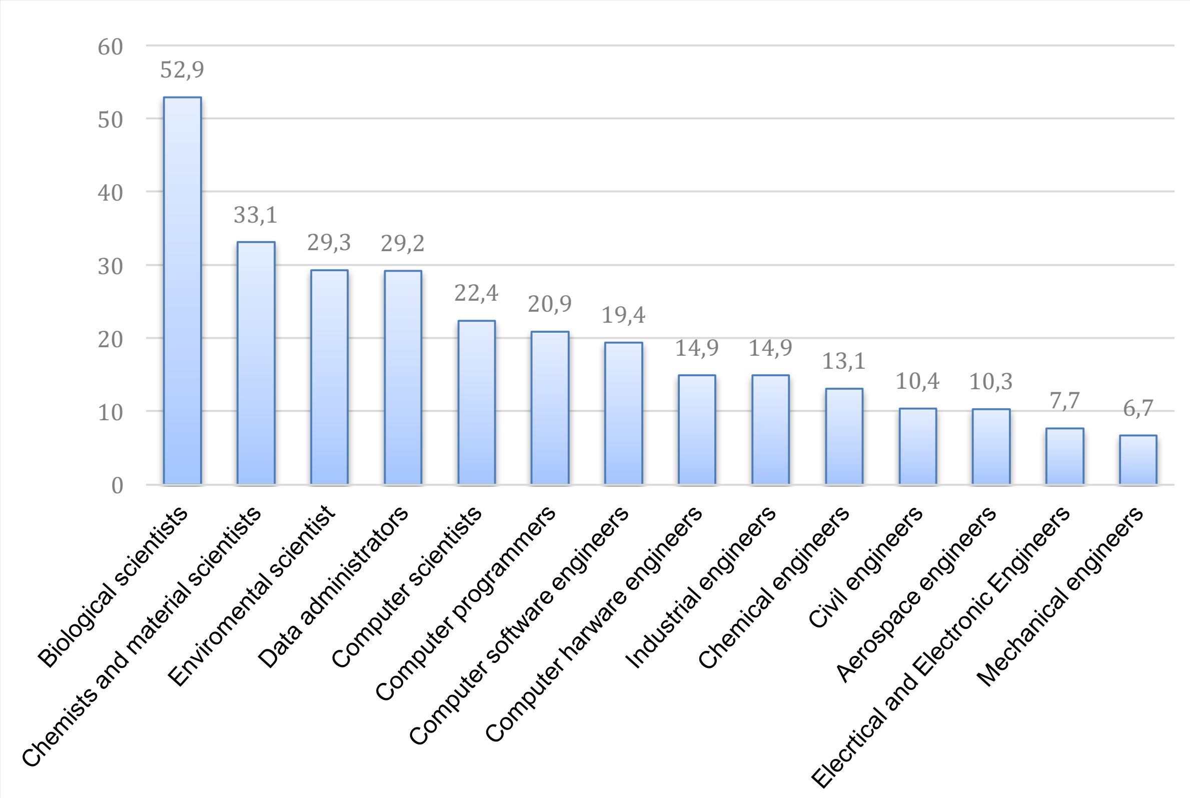

Figure 1 Women in selected STEM occupations, 2008 (Hill et al., 2010)

According to Figure 1, the majority of women working in science-related fields are employed in the biological sciences. Women represent only 10.4% of the people employed in civil engineering; 10.3% of those in aerospace engineering; 7.7% in electrical and electronics engineering; and only 6.7% in mechanical engineering[3].

Between 1999 and 2007 the United Nations conducted a survey to assess the representation of women in various professional fields in North and Latin America, the Arab States, Europe, Central Asia, East Asia, the Pacific and sub-Saharan Africa (compare with "Women in science," 2015). According to this report, women remain the dominant gender in the fields that have been traditionally dominated by them (Mrkic et al., 2010, p. 64), namely education, health and welfare, humanities (arts and social science), business and law. More women than men were found to enter these fields in more than two out of three countries for which data was available. A study undertaken by the Academy of Science South Africa (ASSAf) in 2015 showed that in 69 national science academies in North America, Latin America and the Caribbean states the representation of women was only 12% (Boshoff, 2015, p. 19). The same

[3] The statistics quoted in this chapter are the most recent. Reports from 2016 and earlier refer to the same 2008 to 2011 surveys.

report indicated that in the natural science and engineering, women's membership remains well under 10% in the countries mentioned (Boshoff, 2015, p. 71).

The converse is, as expected, true for careers in science, engineering, manufacturing, and construction, agriculture and services, where men far outnumbered women in these fields in the same countries and during the same time period mentioned above. An interesting observation is that men dominated in careers for which more women than men had initially enrolled at the tertiary level (Cantos, 2016).

However, it should be noted that in some of the countries, which included some of the Arab states, women did outnumber men in science careers. In Bahrain, for example, women constituted 75% of science enrolment. In Jordan and Lebanon female enrolment was 51%; in Oman 56%; in Qatar 69%; and in Saudi Arabia 59%. It is possible that women outnumber men in these countries because men tend to study overseas.

Luk (2010, p. 129) conducted a study to explore the increase in the number of women in higher education and in the labour force in Hong Kong in recent years. She indicated that the number of female managers and administrators had increased by 108% between 1993 and 2005. During the same period, the number of women in professional occupations had increased by 104%. Despite the fact that in Hong Kong the gender gap in educational and career attainment was bridged during this period, women students in engineering and technology constituted only 25.7% of all undergraduates, which contrasts strongly with the 76% women enrolled for undergraduate studies in the arts and humanities, the 68% in social sciences and the 63% in medical sciences (Luk, 2010, p. 130). In fact, the number of women studying science in Hong Kong is decreasing. Guterl (2014, October 1) found the same tendency in his. Munn (2012, p. 130), who conducted research in Great Britain, found that despite the increasing number of women studying for careers in STEM, up to 70% of those women do not actually enter STEM careers.

Another issue that compounds the problem is that a large number of women leave STEM careers and never return (genSET Consensus Seminars, 2012, pp. 15-17). This can be attributed to a number of factors and it is difficult to generalise. Some of the reasons given in the relevant literature are:

a. They would like to devote their attention to their families when children are born.
b. They find it difficult to return after taking time out from work.
c. They take up part-time jobs.

d. They do not have flexible hours in their main careers.
e. They do not receive sufficient acknowledgement in their main careers (Caprile et al., 2012; Hewlett, 2007, p. 29).

Sylvia Ann Hewlett coined the phrase “women taking off-ramps” for the phenomenon of women taking detours from their main careers (Hewlett, 2007, p. 1). According to her, almost 60% of professional women take “off-ramps” during their careers. The main problem is that when these women want to return to their careers, their main work environments make a return almost impossible. Hewlett (2007, pp. 45-48) maintains that women are penalised for taking career breaks. These “penalties” take the form of poor financial compensation, induced guilt for taking time off from their careers and/or the company in the first place, and failure to acknowledge career achievements.

2.4 The sub-Saharan representation of women in science, engineering and technology

The international trend with regard to women in science is reflected in South and sub-Saharan Africa, where women are also not adequately represented in STEM careers. In fact, according to Butler-Adam (2015), the poor representation of women in STEM careers is even more notable in Africa. The problem of the inadequate numbers of women in the various STEM careers is partly the result of poor literacy among women. In the past, the focus of education in sub-Saharan Africa had, to a large extent and for political and economic reasons, been on teaching boys rather than girls (Academy of Science of South Africa (ASSAf), 2011, p. 6; Boshoff, 2015). Boys were prepared for their roles as breadwinners in society, while girls were prepared to fulfil the roles of mothers, homemakers and caregivers (Academy of Science of South Africa (ASSAf), 2011, p. 6; Boshoff, 2015). This approach towards gender roles merely strengthened the gender disparity in terms of more education for boys and less for girls. According to the UNESCO UIS Fact Sheet ("Reaching out-of-school children is crucial for development," 2012, p. 1), 31 million children in sub-Saharan Africa were not attending school. Sub-Saharan Africa accounts for one half of all out-of-school children worldwide. In sub-Saharan Africa almost 12 million girls may never enrol in school (*Reaching the marginalized*, 2010, p. 1). Some of the reasons for this state of affairs are the deep-rooted inequalities linked to wealth, gender and ethnicity ("Reaching out-of-school children is crucial for development," 2012, pp. 5-8). According to the United Nations Education for All Global Monitoring Report (2010) (EFA Global Monitoring Report, 2010), education is the most important factor when trying to rectify gender inequality (Butler-Adam, 2015). Although education is a basic human right, boys are still the recipients of education and opportunities at the expense of girls. Girls living in remote areas do not have easy access to education.

Furthermore, the abovementioned 2010 report stated that almost two thirds of the world's 759 million illiterate adults were women (EFA Global Monitoring Report, 2010, p. 7). In Africa, 38% of women and 46% of men were exposed to education at the primary level only, and only 21% of women received secondary and tertiary education (Butler-Adam, 2015; EFA Global Monitoring Report, 2010, p. 50).

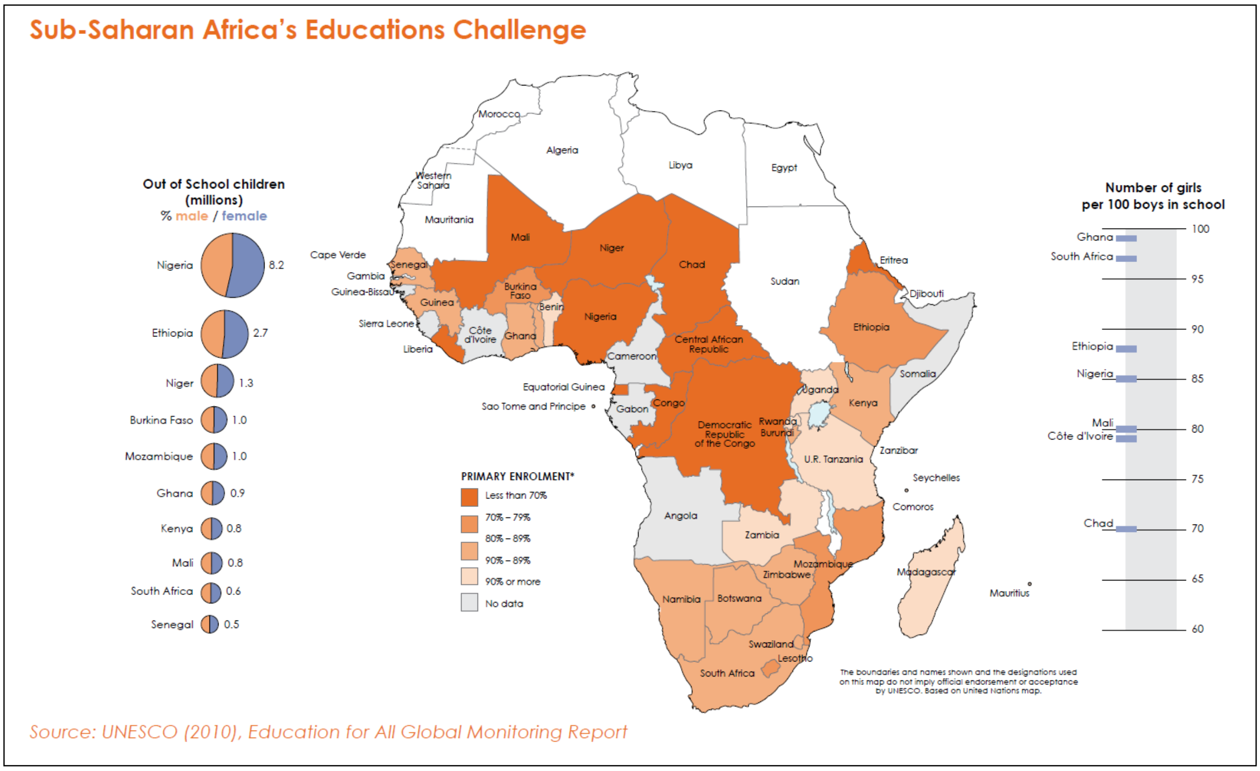

Figure 2 Education challenge: school enrolment in sub-Saharan Africa (from Academy of Science of South Africa (ASSAf), 2011, p. 6)

Figure 2 illustrates the enrolment of children in schools in sub-Saharan Africa. In Ghana and South Africa the numbers of male and female enrolments are almost equal, but the numbers for girls are significantly lower than those for boys in countries such as Mali, Nigeria, Chad, Congo, the Democratic Republic of Congo and Niger (Academy of Science of South Africa (ASSAf), 2011, p. 6).

In sub-Saharan Africa the challenge to increase the number of women in STEM is twofold: first, to increase the number of girls enrolling for primary education and second, to increase the number of girls studying science. Another challenge is to counter the decreasing support

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for basic education in sub-Saharan Africa. According to the United Nations Education for All Global Monitoring Report (EFA Global Monitoring Report, 2010), financial support for education in sub-Saharan Africa has decreased significantly.

In order to ensure better education opportunities for girls, different strategies were developed in the sub-Saharan region. These include the following:

a. The Girls' and Women's Education Initiative of World Education, a non-governmental organisation that promotes initiatives to help girls to remain in school and leverages funding for the education of girls in the region
b. The USAID Africa Education Initiative, which supports education for African girls at the primary and secondary school levels
c. Financial and human resources directed by the World Bank Group, UNICEF and UNESCO to sub-Saharan countries with significant gender disparities in education as part of the EFA Initiative (Academy of Science of South Africa (ASSAf), 2011, p. 7)

Most sub-Saharan governments have used the abovementioned initiatives to prioritise issues related to empowering and educating girls and women, and although there has been tremendous progress in the education of girls in the sub-Saharan region, women continue to be under-represented in the fields of science, technology, engineering and mathematics (Butler-Adam, 2015; EFA Global Monitoring Report, 2010). Some level of gender parity in science has been achieved in two African countries, namely Lesotho (55,7%) and Cape Verde (52,3%). Elsewhere in Africa (excluding South Africa), women represent less than 30% of the workforce in the fields of science and technology (Butler-Adam, 2015; Mlambo, 2011) .

Another global strategy was developed in September 2000 during the United Nations Millennium Summit. The Millennium Declaration developed strategic indicators, or Millennium Development Goals (MGD), to measure the progress made with improving the lives of people in poverty-stricken countries. The Millennium Development Goals (MDGs) are aimed at encouraging development by improving social and economic conditions in the world's poorest countries. The Declaration encourages tolerance and solidarity and states that every individual has the right to dignity, freedom, equality and a basic standard of living, which includes freedom from hunger and violence. The MDGs operationalise these ideas by setting targets and indicators for poverty reduction. One of the intentions of the MDGs is undoubtedly to improve education and promote gender equality in poor countries (Academy of Science of

South Africa (ASSAf), 2011, p. 6). The following eight Millennium Development Goals were developed:

a. MDG 1: To eradicate extreme poverty and hunger
b. MDG 2: To achieve universal primary education
c. MDG 3: To promote gender equality and empower women
d. MDG 4: To reduce child mortality
e. MDG 5: To improve maternal health
f. MDG 6: To combat HIV/AIDS, malaria and other diseases
g. MDG 7: To ensure environmental sustainability
h. MDG 8: To develop a global partnership for development

Two of the MDG goals are directly linked to education and training, namely:

a. MDG 2: To achieve universal primary education
b. MDG 3: To promote gender equality and empower women

Although sub-Saharan Africa supports the Millennium Development Goals, many African countries cannot achieve them due to extreme poverty, hunger and financial crisis (Agenor, Bayraktar, Moreira, & Aynaoui, 2006, p. 1520). However, some countries (Ethiopia, Rwanda, Uganda, Tanzania and Malawi) are making progress. Between 1999 and 2009 the total number of children out of school worldwide decreased from 106 million to 67 million, according to the Millennium Development Goals Report (2010, p. 18). Despite the region's strong efforts to increase enrolment, a large portion (32 million) of the children who are still not attending school live in sub-Saharan Africa. Furthermore, the gender gap remains very obvious and notably more boys than girls enrol at both the primary and secondary levels.

In the most recent report, "The World Women 2010", Mrkic et al. (2010, p. 43) state that in 2007, 72 million children worldwide did not receive primary education. Of the 72 million, more than 39 million (54%) were girls. In 2007, adult illiterates (15 years and older) in Africa totalled 163.4 million, of which 62% were women. (These figures are only for sub-Saharan Africa; northern Africa contributes ± 2.8 million illiterates to the total). It should be clear that the situation in sub-Saharan Africa is extremely worrying. Between 1990 and 2007 the number of adult illiterates in sub-Saharan Africa increased by 29.2 million (32 million for the whole of Africa), of which 70% were women (Mrkic et al., 2010, p. 44). Figure 3 shows that illiteracy in sub-Saharan Africa accounts for 35% of the world total. Illiterate women and girls in sub-

Saharan Africa comprise a staggering 28% of the world's illiterate population total (N = 846,2, according to Figure 3).

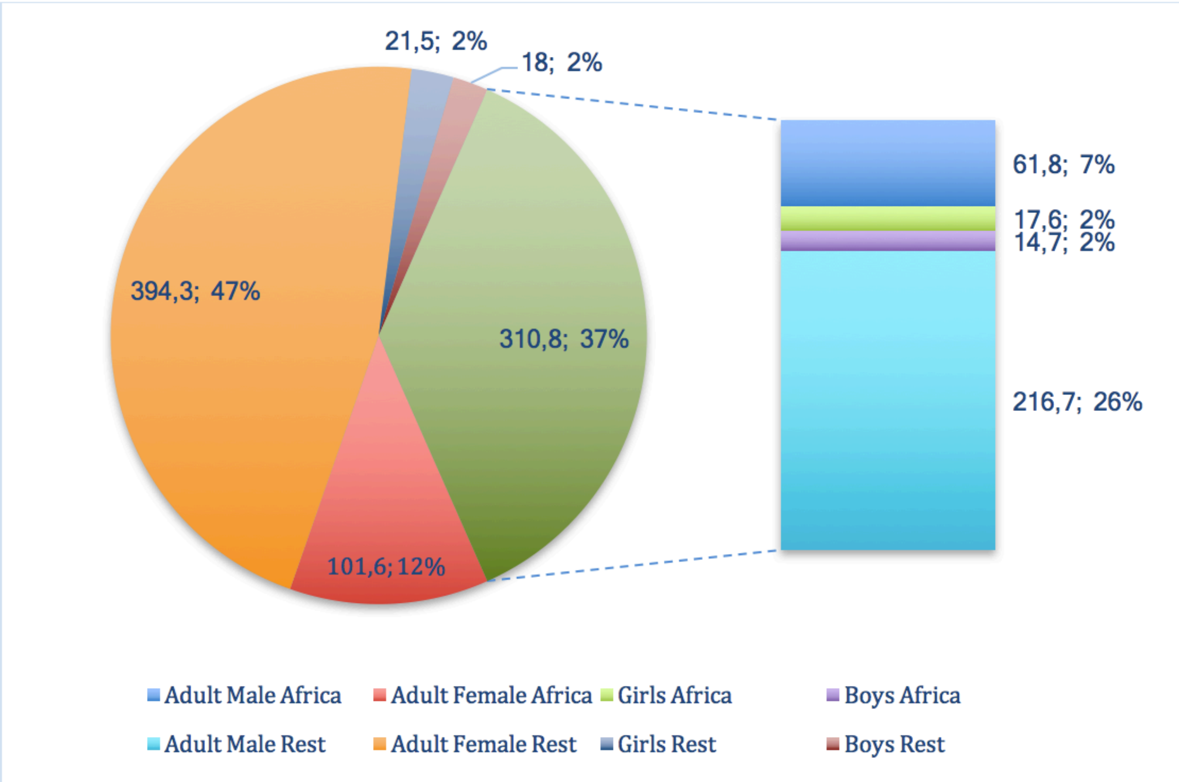

Figure 3 Numbers of illiterate adults and children (millions, %)[4]

Although this thesis does not focus on literacy and its effects, one should realise that illiteracy contributes substantially to the fact that most sub-Saharan countries are poor and experience economic pressure (Academy of Science of South Africa (ASSAf), 2011, p. 8). The prevailing unfavourable economic climate in these countries hampers scientific and technological innovation and is an added constraint on women's entry into STEM fields (Mrkic et al., 2010, p. 68). Increased efforts are being made across Africa to promote women's participation in science. The African Union (AU) declared 2015 as the "Year of Women's Empowerment and Development towards Africa Agenda 2063." This led to the adoption of the "Science, Technology and Innovation" Strategy for Africa (2014).

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[4] See Table 3.1, p. 44 and Table 3.3, p. 55 of Mrkic et al. (2010): the data includes adults (15 years and older) and children of primary school age in the world and sub-Saharan Africa.

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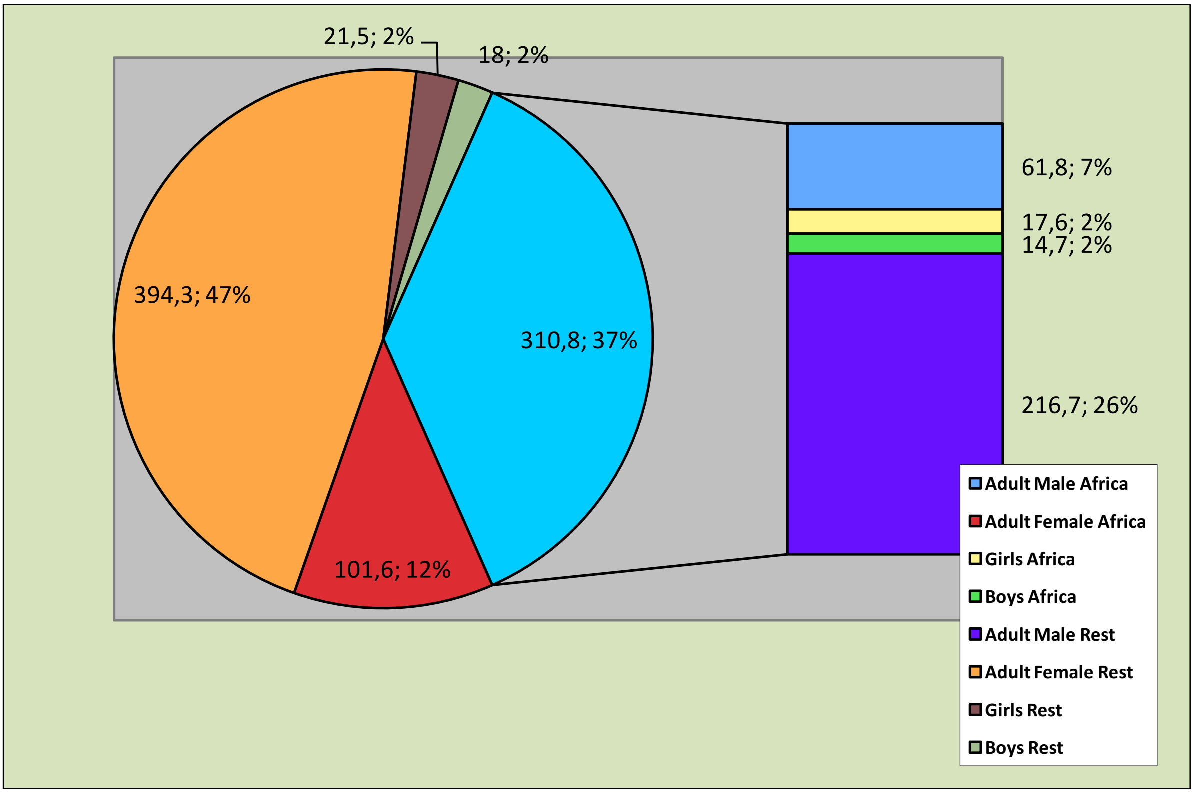

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In the next section the representation of women in STEM careers in South Africa will be discussed.

2.5 The South African representation of women in STEM

The same tendency that is found in sub-Saharan countries can be found in South Africa. According to the report *An assessment of the participation of women in STEM industry* (National Advisory Council on Innovation (NACI), 2008, pp. 13, 17) there is an increase in women students in higher education but they remain under-represented in the STEM sector.

As is the case with sub-Saharan Africa, the lack of women in STEM reflects issues more complex than merely having too few women in the fields. Amongst others there are issues such as the impact of poverty, lack of training and the legacy of apartheid.

Post-apartheid South Africa faced a number of critical challenges with regard to rebuilding the social order after 1994. Several strategies were developed to address these challenges. The education system posed enormous challenges (Kirlidog & Zeeman, 2011, p. 48), and one of most critical challenges was to make education accessible to all. The apartheid government was explicitly opposed to educational equality. According to Kirlidog and Zeeman (2011, p. 48), the 1991 census revealed that only 30% of Black South Africans, compared to 97% Whites, were literate. The Coloured and Indian populations had literacy rates of 60% and 82% respectively. The need to make education accessible to all was an enormous burden placed on the educational system.

In 1994, the newly elected Government of National Unity had to bring a society together through education (Kirlidog & Zeeman, 2011, p. 50). The higher education system was unable to provide the resources needed for economic transformation, in particular in the fields of science, engineering, technology and commerce. The Youth into Science Strategy (Department of Science & Technology (DST), 2006) clearly stated that racial, gender and class disparities still impacted on the science system, and that STEM careers were still dominated by historically privileged persons. Over and beyond racial imbalances, gender imbalances also influenced innovation and economic development and growth.

In 2009 the Minister of Science and Technology, Ms Naledi Pandor, announced that the Department of Science and Technology would deploy strategies to encourage women to participate in STEM careers (2009). Nevertheless it is clear that gender imbalances in the workplace, and more specifically in the STEM sector, still continue and impacts negatively on South Africa's global competitiveness (2008, p. 13). Science and technology are crucial to innovation, productivity and economic wealth (O'Donoghue-Lindy, 2008, p. 4). In order to increase the human capital required to ensure and sustain economic growth, the South African government developed several strategies. One such strategy was the development of the White Paper on Science and Technology (2008), which was published by the Department of Arts, Culture, Science and Technology on 4 September 1996. In the introduction to the White Paper, the erstwhile minister of the Department of Arts, Culture, Science and Technology, Dr B.S. Ngubane, explained the Department's vision as "one where, on the one hand, South Africa uses S&T to become economically competitive on a global scale, and on the other hand to provide essential services, infrastructure and effective health care for all South Africans" ("White paper on Science and Technology," 1996). The former Deputy Minister, Ms B. Mabandla, emphasised the importance of human resources and skills:

> *Also absolutely essential in the implementation of the Growth and Development Strategy are human resources and skills in science and technology. Currently the race and gender disparities in S&T are unacceptably high. We need to address this imbalance pro-actively, not just because it is right to do so, but because if we do not we will simply not have adequate human resources to deal with our problems* ("White paper on Science and Technology," 1996).

Both these former ministers referred to the lack of women in STEM careers. The White Paper led to the establishment of the National Advisory Council (NACI) in 1996. The aim of the Council was to provide policy advice to the Minister of Science and Technology. The NACI established several subcommittees, among others the Subcommittee on Science, Engineering and Technology for Women (STEM4W), which was established to support the NACI in an advisory capacity. A major aim of STEM4W is to guide strategies to achieve gender equality in STEM. The integration of gender equity policies and the implementation of policies in the National System of Innovation (NSI) could, for example, assist in achieving this aim (1996). In June 2015 the African Union (AU) adopted the African Union Heads of States Declaration in which the signatories made a commitment to eliminate all social, political and economic barriers faced by women and girls. It also made a pledge to enhance women and girls' access to education, science and technology. South Africa was a signatory to this Declaration (2015, pp. 1-5).

Greve (2013, p. 12) mentions that despite enabling policies and increased intake of women in the STEM field, the number of women in the field has not increased. The most recent statistics for women in STEM careers in South Africa were provided by StatSa[5]. The number of persons employed in STEM occupations in the third quarter of 2011 (July to September 2011) are provided in Table 3 (Statistics South Africa (Stats SA), 2011)[6]. Note that the percentages are given in rows and show the percentage of males and females in each of the listed careers.

Table 3 Number of employed individuals (age 15–64) by occupation (Statistics South Africa (Stats SA), 2011)

Occupation	Male		Female		Total
	N	%	N	%	N
Physicists and astronomers	1547	100%	0	0%	1547
Meteorologists	1385	100%	0	0%	1385
Geologists and geophysicists	1031	60%	677	40%	1707
Mathematicians and related professionals, analysts and methodology researchers	2340	100%	0	0%	2340
Computer systems designers and analysts	31055	72%	12202	28%	43257
Computer programmers	15783	74%	5660	26%	21442
Computing professionals not classified elsewhere	4105	30%	9671	70%	13776
Architects, town and traffic planners	11904	87%	1796	13%	13701
Civil engineers	19341	90%	2251	10%	21592
Electrical engineers	10974	93%	831	7%	11805
Electronics and telecommunications engineers	599	100%	0	0%	599
Mechanical engineers	13604	100%	0	0%	13604
Chemical engineers	2631	65%	1399	35%	4030
Mining engineers, metallurgists and related professionals	1760	100%	0	0%	1760
Land surveyors, cartographers and other surveyors	6263	88%	818	12%	7082
Architects, engineers and related professionals not elsewhere classified, industrial/production engineers, quantity surveyors, architects, engineers and related professionals not classified elsewhere	12007	89%	1512	11%	13519
Scientists	743	62%	457	38%	1200
Biologists, botanists, zoologists and related professionals	2117	77%	621	23%	2738
Biological sciences, chemical sciences, medical sciences, physical sciences and veterinary sciences	1977	29%	4919	71%	6896
Agronomists, food scientists and related professionals, agriculture, forestry and food scientists, natural sciences technologists	2897	65%	1586	35%	4483

In Figure 4, the information presented in Table 3 is given in the form of a Pareto chart in which the numbers of women in different careers are arranged in descending order. Both Figure 4

[5] Statistics South Africa is the national statistics board of South Africa.

[6] The Quarterly Labour Force Survey (QLFS) is a household-based sample survey conducted by Statistics South Africa (Stats SA). It collects data on the labour market activity of individuals aged 15 years and older who live in South Africa.

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and Table 3 clearly show that women are not well represented in most occupations, especially not in the fields of physics, astronomers, meteorologists, electronics and telecommunications engineers, mechanical engineers, mining engineers, and metallurgists.

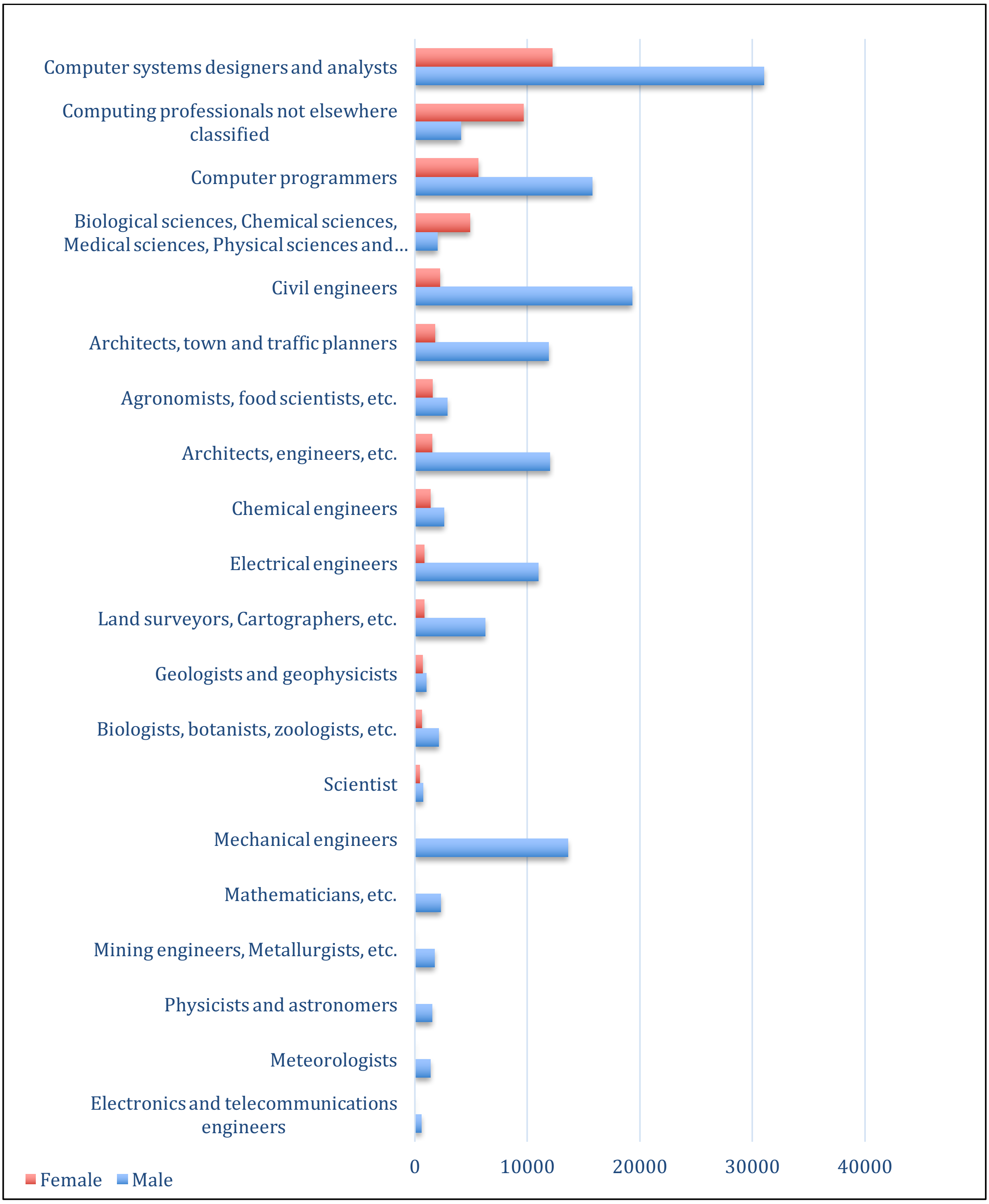

Figure 4 Pareto chart for number of females vs. males in science occupations

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According to the information provided by Stats SA, biological science (which includes medical and veterinary sciences) is the STEM field in which women are best represented (71%). They have a 0% representation in the fields of meteorology, physics, mathematics, mechanical engineering, mining and metallurgical engineering, and electronics and telecommunications engineering. These figures correspond with international figures (see Figure 1), which also indicate that the majority of women working in STEM are employed in the field of the biological sciences. Women accounted for only 7.7% of people employed in electrical and electronics engineering, and only 6,7% of those in mechanical engineering. In 2010 the number of women from all races with all types of education (contact and distance) who were awarded engineering degrees was 1031 (25%), as opposed to 3153 (75%) men (Department of Higher Education and Training, 2014).

The report titled South African Science, Technology and Innovation Indicators 2015, released by the National Advisory Council on Innovation (Jammine, 2015, p. 5), indicated an increase in higher education STEM graduations between 2005 and 2014. In 2005, 27.8% of all graduates received degrees in the STEM fields. By 2014 this percentage had increased to 30%. Female graduates increased from 48.9% in 2005 to 50.2% in 2014. Although this shows positive growth, the number of females opting for careers in STEM is still not sufficient. According to Jammine (2015, p. 4) only 29.6% of all enrolments at South African universities are for STEM degrees (53.3 % are for social sciences, humanities, business and commerce while 17.1 % are for education degrees). Even though there has been a rise in the number of females graduating in STEM fields, the low pass rate for girls in Mathematics and Physical Science in the National Senior Certificate (NSC) examinations during the period 2008 to 2014 is a cause for concern. In 2008, 47.9% of the Grade 12 learners who passed Mathematics with 50% or more were female. In 2015 the pass rate for female learners passing Mathematics with 50% or more dropped to 44.3%. The same tendency was evident in the case of Physical Science, with a decrease in the pass rate for girls from 46.6% in 2008 to 45.8% in 2015 (Jammine, 2015, p. 1). Acceptable pass marks in Mathematics and Physical Sciences are compulsory for enrolment in degree courses in the STEM fields.

In the next section the reasons why women who enter the STEM field often do not remain in STEM careers will be explored.

2.6 Explaining the under-representation of women in STEM

In this section, the reasons behind women's decisions to leave STEM careers will be briefly examined. This particular topic has been extensively researched and discussed in the relevant literature (Blickenstaff, 2005; Etzkowitz et al., 2003; Godfrey-Genin, 2010; Pell, 1996; Rossiter, 1993). Although it is the aim of this study to determine why women stay rather than leave, it is necessary to take cognisance of the usual barriers causing the under-representation of women in STEM.

A popular and overused metaphor used to explain the under-representation of women in STEM is the leaky pipeline (Pell, 1996). It points out the crucial moments in a woman's career development and life milestones that could influence her decision to remain in, or exit her career (cf. the funnel model of Cronin & Roger, 1999). Thus it places the focus on the traditional difficulties faced by women, such as career breaks due to pregnancy and family responsibilities, work culture, such as surviving in a male-dominated environment and atmosphere, and women's expectations and the belief that science is not the appropriate field for them (Donovan et al., 2005). The crucial periods during which leakage can occur are (a) early childhood; (b) adolescence; (c) entry to undergraduate studies; (d) the remaining part of graduate studies; and (e) the job entry time (Pell, 1996) (Figure 5). The leaky pipeline is represented in Figure 5.

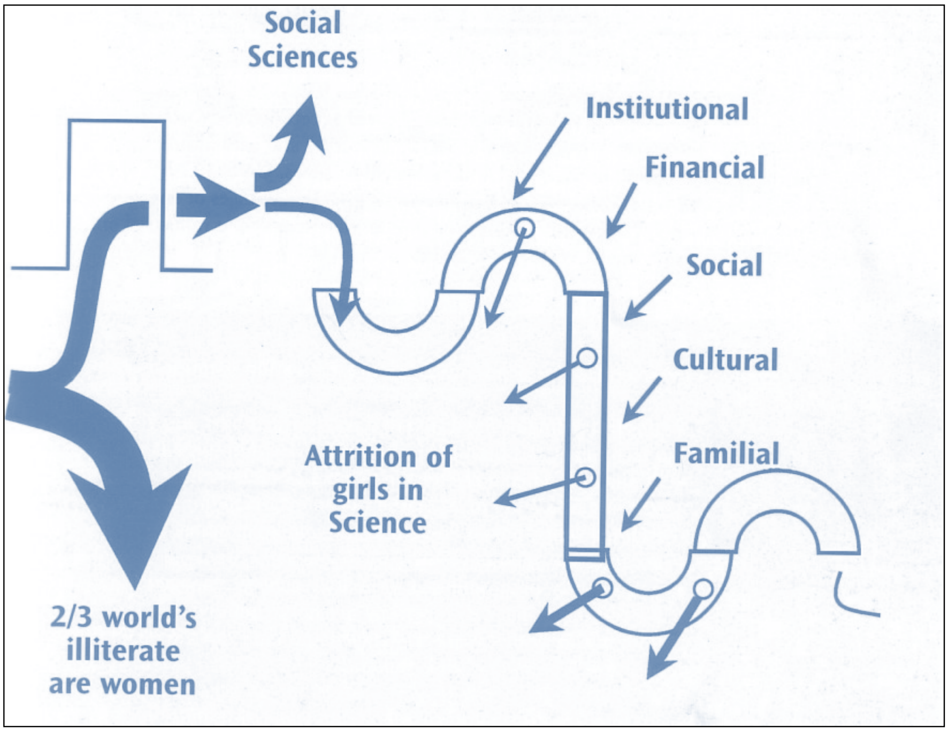

Figure 5 The leaky pipeline (McGregor & Bazo, 2001, p. 49)

The leaky pipeline metaphor serves only as a description for the under-representation of women and not as a comprehensive explanation. According to Blickenstaff (2005, p. 369) the crucial life phases, such as the transition from school to tertiary education, entering a new job and starting a family, place demands on a woman's career development plan. It is these demands that need to be discovered and explored as the reasons for leakage. For instance, on entering a new job, a barrier to be overcome is adaptation to a male-dominated environment. In the LERU research paper (Maes et al., 2012, p. 5), the researcher confirms that even 11 years after the coining of the phrase leaky pipeline, women still leak from the pipeline, causing a loss of human research capacity.

As Blickenstaff (2005, p. 369) points out, it is of course mostly women that leak out of the system while most men reach the end of the pipeline. Therefore, some of the solutions to the barriers that prevent women from entering or remaining in certain careers must focus on the work culture and perceptions within male-dominated careers. Zuckerman and Cole (as cited in Waechter, 2010, p. 49) state that women scientists are "triply handicapped": first, they have to overcome barriers when entering the STEM field; second, they have to break through culturally constructed discrimination; and third, they have to manage opportunity- and reward-based discrimination. Etzkowitz et al. (2003) emphasise the destructive nature of discrimination against women and the intensity of their struggle when they suggest that the initial negative depiction of the leaky pipeline is still too optimistic. The EU report (Caprile et al., 2012, p. 27) mentions that although gender discrimination is prohibited in the 21th century, it still exist in more subtle forms, for example when women are not invited as keynote speakers at conferences, they are not cited, or their work is not read.

Focusing on educational barriers might only partially solve the problem as it has been seen that even in nations where more women than men enrol at universities, fewer women study sciences and technology (Mrkic et al., 2010). Since access to education alone evidently will not increase the numbers of women entering careers in the sciences, other factors that play a role will also have to be considered. Although the participation of South African women in higher education has risen significantly over the past few years, gender-differentiated data show that women are still under-represented in the sciences at both the undergraduate and graduate levels (National Advisory Council on Innovation (NACI), 2004, p. 21). Furthermore, the growing number of women obtaining science degrees does not result in an increase in the number of women working in the scientific labour force, and women who do enter STEM careers do not necessarily remain there (European Commission, 2006).

2.7 Barriers encountered by women

Blickenstaff (2005) used the existing literature to make nuanced and clear distinctions about the barriers women face, thus going beyond the leaky pipeline metaphor or model (Caprile et

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al., 2012; Cronin & Roger, 1999; Lühe, 2014). A critical revisiting of the so-called barriers shows that some do not really present barriers, while others are still very valid and real with regard to their ability to either prevent women from pursuing careers in the STEM fields, or to cause them to leave.

In brief, Blickenstaff (2005, p. 372) mentioned the following barriers (which have been referred to by many other researchers but have not necessarily been categorised as such (Butler-Adam, 2015; Gunter, 2013; Maree & Maree, 2010; Thege, Popescu-Willigmann, Pioch, & Badri-Höher, 2014):

a. Biological differences between men and women in terms of skills and ability prevent women from excelling in STEM.
b. Girls at school are not well prepared for a science career.
c. Girls have a negative attitude towards science and do not have positive experiences of science at school.
d. There are no role models in science for girls.
e. Science curricula do not apply to girls.
f. Pedagogical styles of science classes suit boys better than girls.
g. There is a “chilly climate” towards girls in science classes (Hall and Sandler, 1982);
h. Girls are expected to conform to traditional gender roles, which excludes STEM careers.
i. The worldview imbedded in science is masculine.

Shen (2013) provides a visual presentation of the increase of women in science and the problem of women leaving STEM careers (see Figure 6).

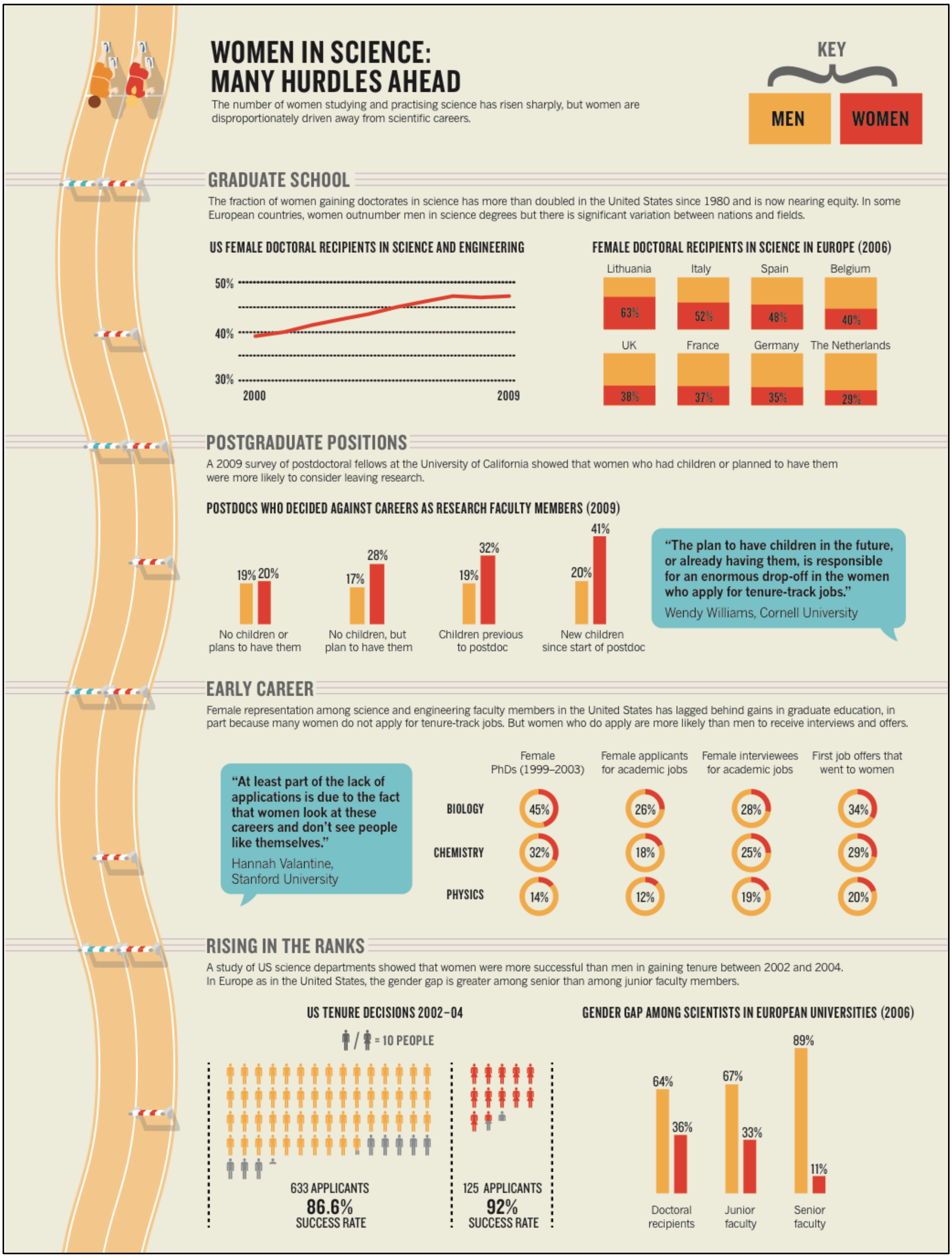

Figure 6 Women in science and barriers faced by them (From Shen, 2013, p. 23)

Figure 6 shows that one of the reasons women leave STEM careers is having a family or the intention to have children in the future. This will be explored in later chapters.

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Closer inspection reveals that the nine types of barriers can be divided into two categories, namely structural and individual barriers (Fox, 1998; Maree & Maree, 2010; Sonnert, Fox, & Adkins, 2007).

2.7.1 Structural barriers

In this study, structural barriers refer to contextual factors that prevent women from moving into the STEM fields. The term contextual refers to environmental, institutional and other factors that need to be considered over and above the subjective factors, i.e. the individual and psychological factors that are located within women and prevent them from perceiving themselves as capable of embarking on a STEM career (see discussion below). Contextual factors or barriers are those issues that appear when people interact with each other. For example, when a woman is exposed to derogatory remarks in the workplace, this takes place between individuals. However, discrimination can also be present at a more stable or "institutionalised" level. For example, discrimination against women could be found in the maternity leave policies of companies. While Ahuja (2002, p. 22) describes structural barriers as "the structures of institutions that limit opportunities for women", the researcher would like to include these in a broader definition of barriers found within in the dynamic social environment, but also in the "stable" structures that came to exist as a result of the dynamic social context. In this sense the researcher then exclude barriers arising from within an individual (Thege et al., 2014).

The structural barriers that will be discussed below, starting with dynamic structures and progressing to stable social structures, are:

a. Role models
b. Teacher's role and pedagogy
c. Classroom climate
d. Gender bias in course design and curriculum materials
e. The Mathilda effect
f. Gender stereotyping
g. Cultural factors
h. Masculine world view

a. Role models

One of the most frequently cited barriers preventing women from entering STEM careers is the lack of role models. As yet, however, there is no answer to the question whether a significant increase in the number of role models will lead to an influx of women into STEM careers, or to women remaining in STEM careers. Blickenstaff (2005) does not think that this will be the case. The assumption of the importance of role models is bolstered by the belief that "(B)y their very presence, role models provide evidence that a successful career in the field is a possible and unremarkable occurrence" (Ahuja, 2002, p. 26). The effect of positive role models still needs to be empirically investigated and this issue will be briefly discussed later on in this study (Buck, Clark, Leslie-Pelecky, Lu, & Cerda-Lizarraga, 2008; Downing, Crosby, & Blake-Beard, 2005; Murrell & Zagenczyk, 2006; Young, Rudman, Buettner, & McLean, 2013).

b. Gender bias in course design and curriculum materials

Blickenstaff (2005) is of the opinion that much has already been done to eliminate gender bias from science curricula materials and design. However, this barrier refers to, for instance, the fact that textbooks as a rule do not use examples of women scientists. The argument is that women would more readily identify with gender-equality examples. Ahuja (2002, p. 25) states that programmes in Information Technology are written with boys, rather than girls, in mind (Thege, 2014), and that complicated programming is therefore based on a masculine approach. This approach can supposedly be off-putting to women in this field.

c. Teacher's role and pedagogy

Teachers are responsible for creating an environment that facilitates science and maths learning (Thege, 2014). Any negativity towards girls perceived in the teacher's approach in the classroom could have a detrimental effect on the girls' interests and choices (Stewart, 1998). The way a teacher acts towards boys and girls can influence children's attitudes, and even a subtle favouring of boys could have a negative impact on girls (Alper, 1993; Blickenstaff, 2005; Caprile et al., 2012). Allowing boys more access to technological environments and discouraging girls from accessing them could further strengthen the message that girls are supposed to conform to gender-stereotyped roles (Caprile et al., 2012; Plumm, 2008). Oakes (2016) notes that a classroom disparity exists that favours boys. According to him, boys get attention, praise and critical feedback, and are encouraged to be assertive. This type of teacher behaviour instils passivity in girls and contributes to them losing confidence in their ability to do science and maths.

d. Classroom climate

The issues mentioned above, namely bias in course materials and teachers treating boys and girls differently, constitute what Hall and Sandler (1982) call the "chilly climate" in the classroom. The concept of the chilly climate is a slightly more fossilised structure than the previous two aspects discussed above. The classroom culture (or context) of negativity towards women in STEM applies on both the secondary and tertiary educational levels (Blickenstaff, 2005). The report, “She figures 2009” (Commission, 2009, p. 39) states that more girls than boys are in fact successful at school. Girls obtain higher marks than boys and repeat subjects or years less often. Despite this, it is still the boys who choose to pursue studies in the scientific, technical and industrial fields while girls choose literature and non-natural science fields. The report also states that one of the reasons for this state of affairs is the continuous gender stereotyping and gender-biased attitudes of teachers towards children. Seymour (1995) also maintains that boys get the better deal in the classroom. The teaching that girls receive, even in same-sex schools, is more passive, less demanding and less experiential, in particular in the fields of science and maths (Seymour, 1995).

Badri-Höher (2014) and Morris and Daniel (2008) conducted a study with college undergraduates in the USA, where females experience the climate at college to be markedly more “chilly” than did their male counterparts. Traditional career female nursing and education majors and non-traditional career majors in engineering and information technology (IT) all experienced gender bias in the classroom, although the non-traditional career majors experienced the classroom as more chilly than the traditional career majors. These findings are supported in “Mind the Gender Gap” (2013) and also by Shen (2013), who agrees with the finding that female science students are usually excluded from class conversations and activities. Kelly Oakes (2016) relates her experiences as a woman in a physics class and how she still (even as a qualified physistist) doubts her ability because of what she experienced as a female in the “male” physics classroom.

Etzkowitz et al. (2003, p. 93) refer to the specific example of a female graduate student who joined a table of male scientists. The professor also present, referred to the women as “my girls”, but never labelled the men as “my boys.” This familiar and patronising behaviour conveys the message than women need not be taken seriously in the science context. Lynne Kiorpes shared her experience as an undergraduate engineering student on the first day of class: The Professor looked around and said, “I see women in the classroom. I don’t believe women have any business in engineering. I’m going to personally see to it that you are failing” (Shen, 2013, p. 22). Mitchley, Dominguez-Whitehead, and Liccardo (2014) further point out that male academic colleagues tend to introduce their male students to important networks, collaborations and research results – a privilege not extended to female students. In the classic work *Athena unbound* Etzkowitz et al. (2003, p. 115) refer to this phenomenon as the “kula ring”, which refers to the tradition among elite men from the Kwakiutl Native American communities to share their most prized possessions with each other. The value of the material goods given away was directly related to increased social status. To return to the previous

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point: By being denied the opportunity to share in the male-dominated networks and collaborations, women scientists are increasingly isolated and marginalised (Etzkowitz et al., 2003, p. 116; Mitchley et al., 2014). Naturally, this isolation prevents women from progressing in their careers.

e. The Matthew/Mathilda effect in science

The Matthew/Mathilda effect is described in an article written by Margaret Rossiter (1993, p. 326). Recent research revealed a number of instances where women's contributions were ignored. Robert K. Merton coined the term the Matthew effect with reference to scientists who do not receive adequate acknowledgement for their work. This is derived from the Bible verse Matthew 13:12, which refers to people not being acknowledged for their contributions. The term was constructed to describe the enhancement of the positions of already eminent scientists who are given disproportionate credit in cases of collaboration or of multiple independent discoveries. Its significance was thus confined to its implications for the reward system of science. The Matthew effect may serve to heighten the visibility of contributions to science by scientists of acknowledged standing while reducing the visibility of contributions by scientists who are less well known.

In 1968 the Mathilda effect was added to express a similar idea. The Mathilda effect refers to the late-nineteenth-century American feminist critic, Mathilda J. Gage, who experienced a lack of acknowledgement for her work (Rossiter, 1993, p. 325). One of the most infamous cases of theft of academic creditability was that of Lise Meitner. She worked for years with Otto Hahn in an area that was later called nuclear fission. In 1944, Hahn received the Nobel Prize for Chemistry. He accepted the prize without a hint of acknowledgement of the fundamental contribution made by Meitner (Rossiter, 1993, p. 329). Rossiter (1993, pp. 325-329) also mentions several examples of women who were not credited for their work and eventually had to resort to publishing their findings under their spouses' names. In the NACi-study, Maree, Maree, Botha, and Gcabo (2008) found that women in different STEM fields needed to work much harder than their male counterparts to prove themselves and to receive some credit from their male colleagues.

f. Stereotyping

Stereotyping cannot be separated from the other abovementioned barriers, some of which influence stereotyping or lead to stereotyping. Stereotyping is difficult to distinguish from socio-cultural factors since cultural views and social norms determine the gender distinctions within families and communities. Stereotyping implies that women should focus on homemaking, raising children and cooking. Men are the breadwinners and the implication is that women should not pursue careers or show an interest in science (Shen, 2013; Urry, 2008).

The expression “Athena bound” is often used in this context (Etzkowitz et al., 2003, p. 15). Athena, the Greek mythological figure, had both male and female elements in her personality. She was one of the three virgin goddesses who did not get married and the possibility of romance and marriage did not feature her mythological narrative. According Etzkowitz et al. (2003, p. 15), women in the STEM field are faced with similar dilemmas as Athena. Contemporary women scientists are required to combine the demands of their personal lives and professional careers without either one affecting the other. Some mythologists even refer to the Greek myth of Athena as the prototype for the contemporary "career woman" (Etzkowitz et al., 2003, pp. 15-16).

Over and above the expectation that women in STEM fields should be able to manage their personal and professional lives with ease and proficiency, it is also expected that they should accept and work in a work environment that was largely developed by men. In other words, women are expected to work in a traditionally male-shaped environment as if gender does not matter (Kassabian & Nedden, 2014).

Another gender stereotype confuses women’s so-called “lack of interest in science” as a lack of ability (Shen, 2013; Urry, 2008), which contributes to the idea that women are not good at science. Beilock, Rydell, and McConnell (2007) conducted a series of experiments examining the cognitive mechanisms underlying stereotype threat. While again confirming the significant effect of stereotype threat on women’s performance on maths test, they found that certain cognitive functions are susceptible to this threat and tends to spill over to other tasks tapping the same functions. The base experiment involved telling one group of women that they are participating in a study to determine why men perform better at maths than women, while the control group did not receive this information. The women in the experimental group fared worse than the control group as expected. Urry (2008) interprets this as a stereotype threat and explains that when people are under stress, they conform to the stereotypical role. In an article written by Helen Shen (2013, p. 22), reference is made to a case study done by Lynne Kiorpes while she was an undergraduate student. On the first day of class the professor looked around and said: “*I see women in the class. I don’t believe women have any business in engineering, and I am going to personally see that you all fail*” The result was that all but one of the female students withdrew from the engineering course.

g. Cultural factors

Different opinions prevail regarding the reasons for women making different career choices than men. Although some authors express the opinion that biological factors play an important role in terms of skill and ability, others place much more emphasis on traditional gender roles and cultural factors (Alper, 1993; Hill et al., 2010; Lühe, 2014; Shen, 2013). In this respect one should therefore ask what the cultural and related factors are that influence the lack of interest in STEM careers noted among girls. Culture influence attitudes and undoubtedly plays a role in the negative view girls have of STEM fields. The long-standing and deeply entrenched belief that science and mathematics are for boys and not for girls probably has its roots in the cultural and gender expectations of communities. Blickenstaff's (2005) example of seating children in a class according to gender perpetuates gender division and opposition within an academic environment and stems from cultural beliefs about gender roles.

These cultural beliefs inform early socialisation, which has an important influence on a child's gender identity (Hill et al., 2010; Roger & Duffield, 2000; Stewart, 1998). As children are exposed to certain behavioural conventions stemming from cultural and social beliefs, ideas about stereotypes are inculcated in them from an early age. Thus, although the role of parents and teachers in forming the child's gender identity cannot be underestimated, the force of culture as a structural or strongly embedded force in society holds both teachers and learners, and parents and children captive. Thus the grip of culturally defined gender roles causes a confusion of biological and social roles (Etzkowitz et al., 2003; Hill et al., 2010). Women are cast in the role of mother and caretaker, which casts doubt on the validity of their role as proficient scientist.

h. Masculine world view

The final and more pervasive structural aspect, which is probably informed by culture, is a masculine world view. This world view underlies science in general and the natural sciences in particular. With reference to this world view, Waechter (2010, p. 43) says: "*In science and engineering hegemonic masculine cultures persist in shaping and influencing academic organisations, their cultures, discourses, and practices.*" The masculine world view is visible in the development of curriculums, learning materials and the approach to knowledge transfer in the classroom.

The masculine worldview finds concrete shape in behaviour, for example in the workplace. Employees are rewarded for supporting this culture of stereotypical and "appropriate" masculine behaviour. Peterson (2010, p. 111) quotes Robinson and McIlwee: *"… to look like an engineer, talk like an engineer and act like an engineer. In most workplaces this means* *looking, talking and acting male.*" The masculine workplace is characterised by behaviour that has the capacity to ignore personal, emotional consideration in order to succeed. In the masculine workplace the standard for promotion and acknowledgement is from the start aimed at the promotion of males. The question that needs to be answered is how the masculine workplace influences women's careers. It ought to be clear that both the masculine workplace and the masculine world view are responsible for women's exclusion and marginalisation in science-related careers.

Blickenstaff's (2005) argument is that external, structural or institutional aspects, such as world views, pedagogical approaches and climates in classrooms, play a bigger role than individual or internal issues (which will be discussed below) in keeping women out STEM fields (Acker & Oatley, 1993; Fox, Sonnert, & Nikiforova, 2009; Rosser, 2003; Settles, Cortina, Malley, & Stewart, 2006; Shen, 2013). One has to ask whether this conclusion is valid, since we might just be living under the illusion that external barriers are easier to change than internal ones. External barriers could be considered as concrete and sometimes easily identifiable, but to change what people think or the underlying discourse, culture or assumptions is not so easy. For instance, negative remarks made about women in the workplace are easy to identify and pinpoint. It also seems easy to put a policy or measure in place to forbid people to make derogatory remarks. However, that there is a deeper or fossilised nature to these barriers is what I would like to convey when calling external or institutional barriers "structural", with all its socio-cultural overtones: it ranges from shallow to deeply entrenched beliefs and traditions. Thus, changing a chilly classroom climate will take more than just making the textbooks woman friendly, but at least this and the attempts to raise awareness by prohibiting discriminatory remarks is a start.

The skewed belief that structural barriers are concrete and thus easy to change deflects attention from the importance of individual factors that might be easier to deal with. The fact that the role of individual factors is less significant than that of external factors could possibly also be ascribed to the tendency of avoiding gender discrimination. It is not fashionable to question women's ability to do science and maths. The assumption is that men and women are equal, and this ought to be the pervasive view when looking at subjective or individual factors. However, just because it is not politically correct to question women's subjective characteristics does not mean that a major cause for "leaking" might not be found there.

The next section will focus on the current state of individual barriers.

2.7.2 Individual barriers

Individual barriers refer to a person's subjective or internal capabilities. Some of these barriers are outlined below.

a. Gender-based differences in ability

Although Blickenstaff (2005) cites some studies that point to differences in the psychological abilities of men and women, other studies found no significant differences between their mathematical and scientific abilities (Alper, 1993; Good, Aronson, & Harder, 2008; Roger & Duffield, 2000; Wyer, Barbercheck, Geisman, Öztürk, & Wayne, 2014). However, this debate is ongoing. Lynn (2008), for instance, contradicts the view expressed by Ceci and Williams (2007) that boys and girls have the same mathematical ability. For Blickenstaff (2005) though, the point is that even if differences do exist, they are so insignificant that they cannot account for the lack of women in the STEM fields. It can therefore be assumed that since there is no difference between the abilities of men and women, the difference in their involvement and performance in the STEM fields is the result of gender influences.

Jochimsen (as cited in Waechter, 2010, p. 45) states that "*different expectations towards men and women influence women's careers in a negative way. They manifest themselves in an often unintended gender bias in current ways of defining and evaluating scientific excellence which might work to the disadvantage of women*." The ideal image of a scientist is one of someone working day and night, and it is of course impossible for women to live up to this expectation because of their home and family duties. (Waechter, 2010, p. 43) conducted a study to find an answer to the question: "Would your career have been different if you were a woman?" When this question was posed to a male focus group, most of the male engineers said that had they been women, their careers would have been "different, slowed down or interrupted."

b. Career preparation

Blickenstaff (2005) argues that even though women are sometimes better prepared than men for a career in STEM, they still exit their STEM studies. Related to this is the point that women have to work so much harder than men to prove themselves capable, especially in their studies (Maree & Maree, 2010; Maree et al., 2008). Thus biological differences and preparation for a career in STEM alone cannot account for why women leave or "leak" from the pipeline.

Etzkowitz et al. (2003) point out the importance of the transition of the student to the research environment. In the work environment the young scientist or researcher learns additional skills when he/she comes into contact with colleagues. Female scientists are mostly regarded by their male colleagues as affirmative action appointments and not as people appointed on merit, which naturally undermines their self-confidence. It also creates and strengthens feelings of incompetence. According to Etzkowitz et al. (2003, p. 70), the transition into the workplace has to be negotiated by means of informal structures that are generally accessible to men, but not to women. Since women are not socialised to understand the political strategies in the workplace, they fail to use these structures to strengthen their careers (Etzkowitz et al., 2003, p. 79; Hill et al., 2010).

c. Attitudes towards science

Blickenstaff (2005) refers to the research conducted by Weinburgh (1995) (Weinburgh, 1995), who found that girls and boys had different attitudes towards science and mathematics, and that girls were less likely to be interested in those subjects. However, according to Blickenstaff (2005) the statistical difference was not very significant. Weinburgh (1995) did find a correlation between a penchant for science and achievement in both boys and girls, and that the girls who really liked science were the ones who achieved high marks in the subject (Weinburgh, 1995, p. 395). Kassabian and Nedden (2014) strongly believe that science will have become gender neutral and gender equal in another 10 to 20 years.

d. Gender stereotypes

The term gender stereotypes refers the idea that a woman's role is to serve, nurture and care (Maree & Maree, 2010; Maree et al., 2008). Women are seen as capable to serve tea, take minutes and do ordinary tasks. If they do not want to cooperate, they are typified as aggressive and difficult. In the workplace women have to cope with insulting remarks about their capabilities and skills. Such continuous derogatory remarks can have a negative impact on a woman's career. This negative impact of stereotyping is called a role stressor (Guterl, 2014, October 1; Hill et al., 2010; Maree et al., 2008; Shen, 2013).

e. Work and personal life balance

Another barrier is the influence of a person's personal life on his or her work life and the balance between the two (Armstrong, Riemenschneider, Allen, & Reid, 2007; Hartman & Hartman, 2008; Morgan, 1992; Özbilgin & Healy, 2004; Shen, 2013). Women often choose to spend time with their families rather than at work. Although some women are very successful at managing to balance work and family life (Maree & Maree, 2010; Maree et al., 2008), this still remains a problem for women entering STEM fields (Etzkowitz, Kemelgor, Neuschatz, Uzzi, & Alonzo, 1994). The decision to expand her family has an impact on a woman's career. Since it implies a career break, a pregnancy must be scheduled carefully (Etzkowitz et al., 1994; Thege et al., 2014). When a woman has to leave her career temporarily due to family responsibilities, the lack of continuity jeopardises her chances of promotion (Armstrong et al., 2007). In "Science is for childless women," Stephanie Diment (1995) discusses the impact of raising a family:

> *I am one of those women who "leaked" out of the pipelines. There is no question that the hours are long and demanding for a bench scientist, and that this is difficult to reconcile with a family. However, the idea of solving this problem by "devoting time to the kids when they are young and coming back to the lab full-force when infant needs abate" is so unrealistic as to be comical. In bench science, no second prizes are awarded, and the economic situation demands unrelenting writing of grant applications and publication of results. I have not met a woman yet who, for example, left a tenure-track position in science to take four or five years out for raising infants and then returned to the tenure track.*

Diment (1995) continues by saying that

> *you will also find very few female scientists willing to discuss their difficulties for fear of being labelled lame ducks within their departments. It is not surprising that many eventually make a heart-wrenching decision to leave bench science to those who have no children or to those who are fortunate to have that acknowledged asset, a wife.*

Godfrey-Genin (2010, p. 93) supports these notions and states that the repressed sexism in a company surfaces when women start their families or want more children. Women are expected not to put their families first, and if they do so they are regarded as unreliable (Godfrey-Genin, 2010, p. 93). A woman in a focus group said:

> *After the birth of my child I was no longer regarded as full-reliable, full-empowered. I felt like having suddenly some kind of handicap. One the contrary, I wanted to be mobile. But people thought that she is now a mother* (Godfrey-Genin, 2010, pp. 74-75).

According to Thaler (in Godfrey-Genin, 2010, p. 75), a myth is created by anticipating problems when a woman starts a family. "Having a family" therefore equals "having career problems." It is of course true that women can struggle with balancing work and personal life, but companies do not provide structural support for employees with families. In most instances company policies in this regard are inadequate. Young mothers are expected to adapt to their careers and young fathers are expected to carry on as before (Bosch, 2012, p. 9; Wyer et al., 2014).

Fixed working hours also create problems for working mothers. They are regarded as the primary caregivers and so must care for their children. The caregiving issues include medical care, after-school activities, special classes, and so on. If they do take time off work they are regarded as lacking in commitment. The fixed working schedule causes some women to start working part time, or to exit their professional careers (Maree & Maree, 2010; Maree et al., 2008, p. 25).

f. The role of self-confidence

Another reason frequently cited for "leaks" is women's lack of self-confidence: "In fact, a loss of self-confidence – rather than any differences in abilities – may be what produces the first leak in the female science pipeline" (Alper, 1993, p. 410; Hill et al., 2010). Although Penner and Paret (2008) found the contrary with regard to mathematics performance, Pell (1996) found that girls' and boys' performance in mathematics is at the same level when they start school, but as they progress the girls perform less well. The poorer performance becomes more pronounced during adolescence, when self-confidence often reaches a low level (Hill et al., 2010; Pell, 1996). In a study involving women who had enrolled for engineering and science courses, (Brainard & Carlin, 1998) found that women started their first year with high levels of self-confidence in their ability to cope with mathematics and science (Hollinger, 1983). However, during the first year there was a significant drop in confidence levels and they struggled to recover their initial levels of confidence during their four years of study. This loss of confidence seemed to correspond with a loss of interest in mathematics and science and increased interest in other subjects, as well as conceptual and learning difficulties (Brainard & Carlin, 1998; Kirkup, 2000).

Even when women working in the STEM fields have exactly the same qualifications as their male counterparts, they tend to believe that they lack the necessary competence and do not feel confident about doing their jobs (Hill et al., 2010; National Advisory Council on Innovation (NACI), 2008; Shen, 2013). This low self-esteem and lack of confidence often results in fear of failure, incompetency and uncertainty, and impact negatively on women's participation and the work environment.

g. Stereotype threat

Although the stereotype threat is discussed under structural barriers, it will also be discussed below as an individual barrier as it has a personal effect on women. Good et al. (2008) draw attention to the stereotype threat, i.e. the belief that mathematics is not for women (Goodrich, 2016, November 7; Wyer et al., 2014), which can have a negative effect on women's performance in this field. However, they also observe that women who were not exposed to a stereotype threat outperformed their male counterparts. Thus the stereotype threat, when encountered, probably combines with the other factors already mentioned to influence women's the self-belief and self-confidence, which can be subsumed as self-efficacy beliefs.

In the next section, the impact of the barriers will be discussed.

2.8 The impact of structural and individual barriers on women's careers in the STEM field

In the previous section the structural and individual barriers encountered by women in STEM careers were discussed. Barriers make it difficult for women to enter STEM careers and if they do succeed, some of these barriers cause them to exit prematurely from their professions (Boshoff, 2015; Commission, 2003; Maree & Maree, 2010; Maree et al., 2008).

A number of strategies are being implemented worldwide to remove the barriers and stop the leakage of women from STEM fields (Blickenstaff, 2005, p. 370). One of these strategies is to provide educational programmes to sensitise STEM students about gender issues in order to create a gender-sensitive workplace (2013; Lynch & Nowosenetz, 2009, p. 568). Other programmes focus on encouraging an interest in science in girls at school level (Blickenstaff, 2005, p. 370). Such programmes are implemented in several countries. For example, the University of Pretoria in South Africa presents the UP with Science and Sci-Enza programmes (http://web.up.ac.za/default.asp?ipkCategoryID=2051). Although both these programmes are focused on both boys and girls, a special effort is made to include more girls and to stimulate their interest in science. In several European countries this is done by organising Girls' Days, Bring a Girl to Work Days and motivational talks at schools (European Commission, 2006, pp. 13,55). Many companies also try to retain women in STEM fields by implementing women's advancement programmes that focus on the reconciliation of career and family responsibilities (Godfrey-Genin, 2010, p. 170).

White (2010, pp. 86-88) discuss a number of programmes, such as the Grace Hopper Celebration for Women and Computing programme, Techleaders, Women of Vision, Sisters, MentorNet and Sister-in-Science. Milgram (2011, p. 7) discusses strategies such as providing outreach materials for future female students, outreach programmes for female students and girls-only events.

The publication Academy of Science of South Africa (ASSAf) (2011, pp. 8-11) discusses inquiry-based science education as a strategy to develop an interest in STEM among girls. Milgram (2011, p. 6) discusses motivational programmes for women working in science with a key message in support of work-life balance with slogans such as "Yes, you can!" In 2013, the former President of America, Barack Obama, launched several programmes, including the Educate to Innovate campaign, the Invest in Innovation Fund and Cross-Agency Priority (CAP) to provide educational support for women studying in the STEM fields (2013).

The abovementioned programmes and strategies (and numerous others not mentioned here) address the different aspects of the "leaky pipeline", but despite all these efforts the number of women working in STEM fields remain low (Blickenstaff, 2005; Boshoff, 2015; Butler-Adam, 2015; Cantos, 2016; 2013; genSET Consensus Seminars, 2012; Guterl, 2014, October 1; Munn, 2012; Shen, 2013; Wyer et al., 2014).

2.9 The importance of women in STEM careers

It is important to understand why more women should be involved in the STEM fields, and what they can contribute to STEM. The reasons for this can be briefly summarised as follows:

a. Women bring new dynamics to the STEM workforce and can contribute towards innovative and ground-breaking ways of solving problems (Academy of Science of South Africa (ASSAf), 2011, p. 8; Boshoff, 2015).
b. Adequate representation of women in the STEM fields promotes gender equality. In this regard Blickenstaff (2005, p. 370) states: "Every person should have an equal opportunity to study and work in the discipline she or he chooses."
c. Sufficient representation of women in the STEM fields contributes towards research quality (genSET, 2011, p. 4; Muthumbi, 2015)TRD, 2015. Science and technology can only achieve greater heights if it incorporates a diversity of perspectives to solve problems (Blickenstaff, 2005, p. 370). According to the Feminist Standpoint Theory, science ought to be practised by women because they are traditionally outside the dominant social order (Harding, 1991). The fact that they operate from "outside" implies that they probably have a more objective view of the world than men.
d. Including women can maximise innovation, creativity and productivity (Academy of Science of South Africa (ASSAf), 2011, p. 8; genSET, 2011, p. 4). A great number of talented women follow other careers (Blickenstaff, 2005, p. 370; Muthumbi, 2015) TRD, 2015). A report by the European Commission (European Commission, 2006, p. 6) calls the lack of women in STEM a "waste of talent." According to Hill et al. (2010,

p. 3), a sufficient number of women is required in the STEM fields to ensure innovation, creativity and competitiveness. For example, product design usually does not take the needs of women into account. Another example is the development of voice-recognition systems, which in the early stages were developed using only male voices.

e. Women can promote structural change (genSET, 2011, p. 4). This means that they can lobby to change the circumstances that cause women to leak out of the system.
f. Women's contributions will increase the workforce and are therefore of crucial importance for the national economy (Cantos, 2016; Caprile et al., 2012; Hill et al., 2010, p. 2). The development of a strong and diverse STEM workforce is of the utmost importance for any country's fiscal and social growth and development.

2.10 Conclusion

Despite the barriers discussed in the sections above, there are women who are successful in STEM careers. Investigations indicate that self-efficacy might play a prominent role in their success. However, since studies undertaken to date have not included the women who have leaked from the pipeline, one cannot be sure of the actual role played by self-efficacy. The concept of self-efficacy has its origin in social cognitive theory, which currently falls under the broader field of positive psychology. The social cognitive theory will be discussed in Chapter 3.

From the above it is clear that although women do not currently participate in sufficient numbers in STEM careers, their involvement in STEM fields is integral to the economic growth of any country (Cantos, 2016; Caprile et al., 2012; Hill et al., 2010, p. 2). The National Science Foundation estimated that about five million people work in STEM fields. This is about four percent of the workforce, which is an alarmingly small percentage when one considers the fact that they are responsible for the bulk of a country's economic growth and development (Hill et al., 2010, p. 2). In this small segment women are in the minority by far. By increasing the number of women in STEM, the worker corps in STEM fields can also be increased. The importance of attracting and retaining women in these fields has become critical.

While the focus in other research, both past and recent, has been on the reasons for women's reluctance to participate in STEM careers, this thesis focuses on the role of self-efficacy as a determining factor in women's decision to either continue working in STEM fields, or leave their professions.

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CHAPTER 3

SOCIAL COGNITIVE THEORY AND CAREER DEVELOPMENT

3.1 Introduction

This chapter will focus on the role of self-efficacy in women who have achieved success in the fields of science, engineering and technology despite the barriers discussed in Chapter 2. Research indicates that self-efficacy might play a prominent role in their success (Zeldin et al., 2008). However, since studies undertaken to date have not included the women who have leaked from the pipeline, one cannot be sure of the role played by self-efficacy.

The concept of self-efficacy has its origin in Social Cognitive Theory, from which its context and theoretical power are also derived (Bandura, 2012, p. 11). Social Cognitive Theory informs specific career development theories, which utilise many of the principles of Social Cognitive Theory. Of course, a number of constructs are acknowledged and utilised in Social Cognitive Theory and many of those are also applicable to career development and success. A few scholars who have examined self-efficacy have found promising results in terms of the relationship between self-efficacy and career development and success (Abele & Spurk, 2009; Brown & Lent, 2016; Fan, 2016; Garcia, Restubog, Bordia, Bordia, & Roxas, 2015; Inda, Rodríguez, & Peña, 2013; Lee, Flores, Navarro, & Kanagui-Muñoz, 2015; Valcour & Ladge, 2008). Peripheral or similar constructs were also investigated, but it seems as if self-efficacy, as it is defined in Social Cognitive Theory, is the characteristic that is most likely to promote career success (Brown & Lent, 2016). As will be seen below, the way Social Cognitive Theory is formulated with reference to the dynamic interaction between agent and environment allows self-efficacy to fit well within the theory. These career development theories, based on Social Cognitive Theory, emphasise self-efficacy (Brown & Lent, 2016). According to Maddux (2005, p. 279) "*self-efficacy can be understood best within the context of Social Cognitive Theory because one of the elements"* of the latter is an agent's interaction with the environment.

In the sections that follow, the background of self-efficacy within the theory of social cognition will be discussed and an attempt will be made to carefully circumscribe self-efficacy. The role of self-efficacy in career development approaches will be discussed in order to gain an understanding of its role in career development.

3.2 Social Cognitive Theory as a theoretical point of departure

3.2.1 Introduction

When reading Bandura's work, the content seems misleadingly simple and the reader is not always aware of the broad history behind its development. Bandura wrote a number of articles and books that present his Social Cognitive Theory as a coherent system. Some overviews seem so broad and general that they encompass most of the aspects a person might encounter in his or her life. For instance, when discussing agency, Bandura (2006b) touches upon the serendipity of events that might or might not influence a person's decisions, and even issues such as morality and moral decisions. However, one should realise that there are a few core principles in his theory that make it possible to make inferences and predictions about human behaviour that to us might seem almost common sense. On a number of occasions he also relates his hypotheses about human functioning to empirical studies and is able to make statements about the effect of self-efficacy on behavioural change. Another aspect that is not all to readily apparent in his discussions about human behaviour, is his clear grasp of scientific principles in the study of psychology, from which many aspiring psychologists can learn a great deal. However, this is not the main focus of this study.

It is not necessary to include a detailed discussion of how Bandura's thinking developed over time, although this might help the reader to fully appreciate the depth of his psychology. It would be helpful though to mention a few interesting aspects on which Bandura based his theory. In this regard it might be surprising to learn that behaviourism formed a constant backdrop, especially in his earlier discussions of his theory (Bandura, 2004b, pp. 617-618; Ferrari, Robinson, & Yasnitsky, 2010, p. 109). However, Bandura (1996) later clearly demarcated his theory from behaviourist theory. More recent reports on his work almost ignore these influences, but a brief discussion will emphasise the richness of Bandura's social learning or Social Cognitive Theory (SCT). In a certain sense, SCT could be classified as a personality theory as it focuses on the internal drivers of behaviour, in other words, on the unseen forces that shape behaviour (Bandura, 1999a). However, having its roots in behaviouristic principles might preclude it as a comprehensive and dynamic theory of human functioning since behaviourism is, among other things, not known for its personality theories! Bandura moves beyond what behaviourism taught: Social Cognitive Theory is an approach to understanding human cognition, action, motivation, and emotion. It assumes that people are capable of self-reflection and self-regulation, and that they are active shapers of their environments, rather than passive reactors to them (Maddux, 1995b, p. 4).

Although Bandura's theory developed over many years, he recently reiterated the importance of both the individual and the social dimensions of human functioning (Bandura, 2006b). He acknowledges the importance of social elements in shaping human development (Bandura, 2006b, pp. 165, 169-170) and provides a balanced view of the interplay between individual and social factors in human functioning (Bandura, 2006b, pp. 165, 166). Whereas social constructionists in their various forms tend to over-emphasise the influence of social aspects on human functioning, Bandura (2006b, p. 168) maintains that individualistic elements remain important (Liebrucks, 2001). In fact, the individual acts despite the social, but is also shaped by it: "*People are producers as well as products of their social environment*s" (Bandura, 1997, p. vii). Bandura (1997, p. 5) thus rejects dualism in social-agency contexts and views the influence of the social and the individual as bi-directional and reciprocal. This particular understanding is not contextual, as is the case in social constructionism or its weak forms, but views the agent as perspectival when switching between individual and social contexts. The individual does not become completely social or the object of a social perspective: the individual retains her or his agency, but is simultaneously part of the social (Bandura, 1997; 2012, p. 11). The individualistic element of the individual-social model that Bandura (2004a) constantly emphasises is agency. The agency-structure polarity is commonly encountered in both social psychology and sociology. While the individual does thus retain a certain measure of control, his/her actions are co-determined by social and other factors (Bandura, 2006b). According to Bandura (1997), dualism regards people as both subjects and objects. When they act they are subjects, but when they reflect on themselves or others they are objects. This dualism is merely perspectival (Bandura, 1997, p. 5).

3.2.2 Behaviourism

Modern ears tend not to be highly attuned to behaviourism and one should distinguish between the various forms. In psychology, behaviourism refers to behaviour in response to a stimulus (Graham, 2015). This may be a gross simplification, but it does enable one to understand the basic principle. The formula stimulus + response = behaviour therefore forms the basic structure of the behaviour of human functioning, and indeed of the functioning of any biological organism (Hergenhahn & Henley, 2014, pp. 375, 385, 395). If one thinks carefully about this, human behaviour might be reduced simply to stimulus and response. For example, in order to brush my teeth efficiently (i.e., the stimulus is: I want clean teeth), I need to respond or behave in a certain way. The problem is that the concrete nature of stimuli can be a problem for some behaviourists, and here we have the behaviour of pigeons in mind. Giving a food pellet as a reward for the desired response is a classic example of stimulus, response and enforcement. However, a stimulus does not always elicit a response. Regular behaviour can only be achieved if certain behaviours can be reinforced by some kind of reward or discouraged by some kind of punishment (Delprato & Midgley, 1992, p. 1515). The behaviourist principles play a role in learning behaviour in a mechanistic way. The mechanistic nature of behaviourism is one part of the theory. Some behaviourists believed that the mind does not play a role in behavioural functioning (Graham, 2015). What is regarded as consciousness or awareness need not play a role in survival: behaviouristic principles are sufficient to explain behaviour.

Rotter's (1982) social learning theory, which was based on behaviourism, cognitivism and personality theory, was further developed by Bandura (Gibson, 2004). The concepts of behaviour potential, expectancy, reinforcement value and the psychological context were used by Rotter to construct a model for predicting behaviour (Gibson, 2004, p. 194). Rotter (1990) is better known for the concept of external and internal locus of control, which stemmed from his social learning theory. Bandura is regarded as the first scholar to emphasise the importance of self-efficacy (Betz & Luzzo, 1996, p. 414), which he described as one of the "*major mediators of behaviour and behaviour change*" (Betz & Luzzo, 1996, p. 414). When reading Bandura's earlier work, terms such as determinants of behaviour, an emphasis on behaviour and changing behaviour are noted (Bandura, 1977a, p. 140; 1977b, pp. 57-158). The legacy of earlier behaviourism can still be seen in our definition of psychology as the science of human behaviour, which does not always hold true: while our behaviour is always caused by something, not all causes have overt behavioural effects. Causes of or determinants of behaviour can be either external or internal, and theorists tended to emphasise the role of the environment and people in the environment that determines behaviour (Delprato & Midgley, 1992). One example of how Bandura and his peers moved beyond mere reactive models of behaviour is that they realised that although people do react to the environment, they also change it. They therefore concluded that determinants are reciprocal, which led to the development of Social Cognitive Theory. Social Cognitive Theory acknowledges the reciprocal influence of environmental or social aspects, and the cognitions of the individual (Bandura, 1977b, 1999b).

3.2.3 Social Cognitive Theory

The environment-behaviour structure was expanded in Bandura's (1986) Social Cognitive Theory in which determinants of behaviour are still present, but the environment includes other people as well, and the individual organism with its "internal" stimuli also plays a fundamental role in executing behaviour (Bandura, 1996; 2006b, p. 165). For instance, if we have a patient with a fear of spiders (arachnophobia), spiders as the environmental stimuli obviously determine the fearful response. As in the case of Pavlov's dogs, the typical behaviourist question would be whether one can train a person to react less fearfully to spiders. Methods such as desensitisation, i.e. gradually diminishing the fearful response, seem to work well with spider phobias, but the limits of behaviouristic principles were reached when psychologists realised that learning is neither associative nor mechanistic. Something more than a mechanistic association was required for a person to *realise* that (some) spiders are innocuous (Bandura, 1982, pp. 138-139).

Bandura found that this realisation, which was the one ephemeral element that the behaviourist had failed to account for, is the most important element in the make-up of an adequately functioning human being. This is the element that enables a person to be a determinant in his/her surroundings and not merely a passive receiver of stimuli prompting specific behaviour Bandura (2006b). Bandura (2006b) calls this element agency. It is the main behavioural determinant and the principle on which he based his psychology of human functioning. Agency immediately changes the relationship people and their environments and provides a way to describe behaviour from birth to old age and to predict behaviour (with certain restrictions) (Bandura (2006b). It also enables the therapist to change behaviour, not in a mechanistic manner, but by taking into consideration the elements that influence agency and the elements influenced by it. Bandura fully realises that, as is the case with all theories relating to human functioning, from psychodynamic to humanistic theories of various types, the extent to which his theory can explain human functioning will ensure its robustness as a theory (Bandura, 1982, p. 123; 2012). The question about whether this explains more or less than other theories do, will have to be answered by another study; Bandura (and others) examined empirical evidence for the mechanisms proposed by him.

3.2.4 Agency

Why is agency important? Clearly a behaviourist conception of functioning is passive-reactive: something responds only in reaction to a stimulus. However, Bandura (2006b, p. 164) says "*To be an agent is to influence intentionally one's functioning and life circumstances*" (also see Bandura, 2012, p. 11). "*To intentionally influence,"* first encapsulates the idea of doing/intending something wilfully and, second, suggests a causal effect (Bandura, 2006b, p. 170). Being an agent is thus to experience oneself as a causal source for effecting change. Human agency has four properties:

a. Intentionality
b. Forethought
c. Self-reactiveness
d. Self-reflectiveness

These properties will be briefly explained below.

3.2.4.1 Intentionality

Intentionality describes the intention to act and the plans one puts in place to realise those intentions, and plays an important role in the self-regulation of behaviour (Bandura, 2006b). Jungert (2009, p. 14) summarises the Social Cognitive Theory as a model that sees humans as self-organising, proactive and self-regulating. Self-regulation refers to aspects such as thinking, motivation and behaviour during the execution of a task. Self-regulated individuals set goals for themselves and control their cognition and motivation to formulate strategies to achieve their goals (Jungert, 2009, p. 14). According to Bandura (1986, p. 467), intention is defined as "*the determination to perform certain activities or to bring about certain future state of affairs."* This definition of agency is close to what Snyder, Rand, and Sigmon (2005) view as hope. Whether one agrees with this definition is not relevant, but the fact that hope is defined as entertaining agency and pathway thoughts applies directly to what Bandura believes about intentionality as a characteristic of agency. Snyder et al. (2005) view hope as the ability to intentionally act, but also the ability to find avenues for realising those intentions. The elements of both intentions and the realisation of those intentions are present in Bandura's (2006b, p. 164) concept of intentionality: "*People form intentions that include action plans and strategies for realizing them*." The ability to form intentions is thus the main part of the active, self-propelling core.

One should realise that agency is never absolute because people may act on their own, but usually require other agents to fulfil their desires, needs and goals: Bandura (2006b, p. 164) calls this collective agency.

3.2.4.2 Forethought and self-reactiveness

Forethought includes the ability to direct one's actions towards the achievement of a goal based on the anticipated outcomes of future behaviour (Bandura, 2006b, p. 164). The concept of anticipation is important in this regard. By forming expectations of possible events or goals that might be realised, these anticipations function as motivators[7] for behaviour Bandura (2006b). It is interesting to note that the ability to form expectations is a cognitive ability to, in a certain sense, concretise imagined events Bandura (2006b). Thus, in contrast to the behaviourist view, the element required between a stimulus and behaviour is a cognitive

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[7] Bandura (2006b, p. 164) points out that the future cannot function as a pull factor to enable action. It is rather internal push factors that determine behaviour.

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appraisal of some kind. In this instance, it is the anticipation of a future event (Bandura (2006b). According to Bandura (1986, p. 19), people do not merely react to (only) the immediate situation or incidents of the past. They respond purposefully because of forethought. People expect specific actions to have specific outcomes and make future plans around those expectations. This ability to be reactive in response to plans is called *self-reactiveness.* Thus, the first property of agency (paragraph 3.2.4.1 above) involves a plan to act or a plan to achieve a goal. The third property of agency, self-reactiveness, stipulates that human beings should be active in order to realise their initial intentions. They are therefore initiators of action.

3.2.4.3 Self-reflectiveness

The realisation that in order to achieve an envisaged goal one needs to make plans and do things in a purposeful way will be of no use if one lacks the ability to utilise information about how close one is to a particular goal. Since human beings have the ability to abstract and symbolise experiences (Bandura, 1977b, pp. vii, 13), they can create internal representations of experience. They are also able to construct new courses of action and conceptually assess the outcomes and their effects (Bandura, 1986; Maddux, 1995b). People also have the ability to communicate these complex ideas to others. The last property of agency, namely *self-reflectiveness,* stipulates that people can monitor their own actions: "*Through functional self-awareness, they reflect on their personal efficacy, the soundness of their thoughts and actions, and the meaning of their pursuits, and they make corrective adjustments if necessar*y" (Bandura, 2006b, p. 165). Self-reflectiveness enables people to exercise control over their thoughts and behaviour. A consequence of metacognitive capabilities is the ability to self-regulate (Thomas, Anderson, & Nashon, 2008, p. 1702). Human beings therefore have the ability to control their behaviour.

3.2.4.4 Summary

The four properties of agency, according to Bandura, are: *intention, envisaging, action and correction*. One might think that these properties are sufficient to describe what happens when an individual try to realise her goals, but as one knows from behaviourism (and personal experience), acting in a world consisting of events and containing other agents does not make for a smooth ride. Individuals change things in the environment and impact on other people, but the converse is also true: things happen and these events and other people have an impact on the individual. One could say that internal and external factors impact on any agent's behaviour. The determinants of behaviour reside within and outside a person, and the interplay is so complex and dynamic that Bandura called it *reciprocal determinism*. One should not be misled by the term determinism, which in this case does not mean deterministic in the sense of when one mechanically turns a knob or pushes a button, a series of predetermined and predictable events will follow. Bandura uses the term determinism to refer to how, although everything is determined by something else and has a cause, this does not affect personal freedom: "*Due to the interdependence of behaviour and environmental conditions, determinism does not imply the fatalistic view that individuals are only pawns of external influences*" (Bandura, 1977b, p. 206). Reciprocal means that something works in both directions. In simple terms, one can say that the environment changes us and we change the environment.

It is interesting to note that Bandura talks about *triadic* reciprocal determinism. The three elements of this type of determinism are discussed below.

3.2.5 Triadic reciprocal determination

Reciprocal determinism means that things inside and outside a person cause behaviour in a complex and codetermined way, and are responsible for agency. Bandura (1986) responded to this bipolar model by postulating a *triadic* model of psychological functioning with three components (
Figure 7). His principle of triadic reciprocal causation, or triadic reciprocity, is one of the most important assumptions of the Social Cognitive Theory (Zikic & Saks, 2009, p. 118). The three components identified by Bandura are the behavioural, intrapersonal and environmental components. Two of these refer to the internal and external determinants mentioned in paragraph 3.2.4 above, i.e., the so-called stimulus conditions of behaviour. The third refers to the behavioural response (Bandura, 1986, pp. 22-23). In the behaviouristic model, responses are caused by stimuli, so it is obvious that we have internal stimuli such as feelings, hunger pangs and pains that can affect behaviour. It is also obvious that environmental stimuli, such as being chased by a dog and people saying hurtful things can affect our behaviour. Both internal and external determinants have an effect on behaviour and this constitutes the third component of Bandura's model (Bandura, 2012). However, Bandura describes his structure as follows, specifically calling behaviour a determinant: "*In this triadic codetermination, human functioning is a product of the interplay of intrapersonal influences, the behavior individuals engage in, and the environmental forces that impinge upon them*" (Bandura, 2012, p. 11). The three components are determinants of human *functioning.*

The model simply indicates the reciprocal influences between behaviour and the environment, behaviour and internal factors, and interestingly, between the environment and internal factors (Zikic & Saks, 2009, p. 117). If these particular reciprocal relations were not present in Bandura's (2012, pp. 11-12) model, the behaviourist substrate would have been much more evident (Bandura, 1986, p. 22). The question that now arises is: How do internal and external stimuli influence each other? The main idea of this model is to emphasise the *reciprocal* influence of determinants (Bandura, 1986, p. 23): "*In these agentic transactions, people are* *producers as well as products of social systems*" (Bandura, 1996, p. 340). Obviously, this conceptualisation goes much further than an action-reaction model, whether uni- or bidirectional (in the sense of seriality of events), but it is also not a holistic model of simultaneous reciprocal causation (if such a thing exists). However, Bandura (1986, p. 29) maintains that despite the interrelations being complex and/or multifarious, determinants and effects are sufficiently segmented to allow for their study.

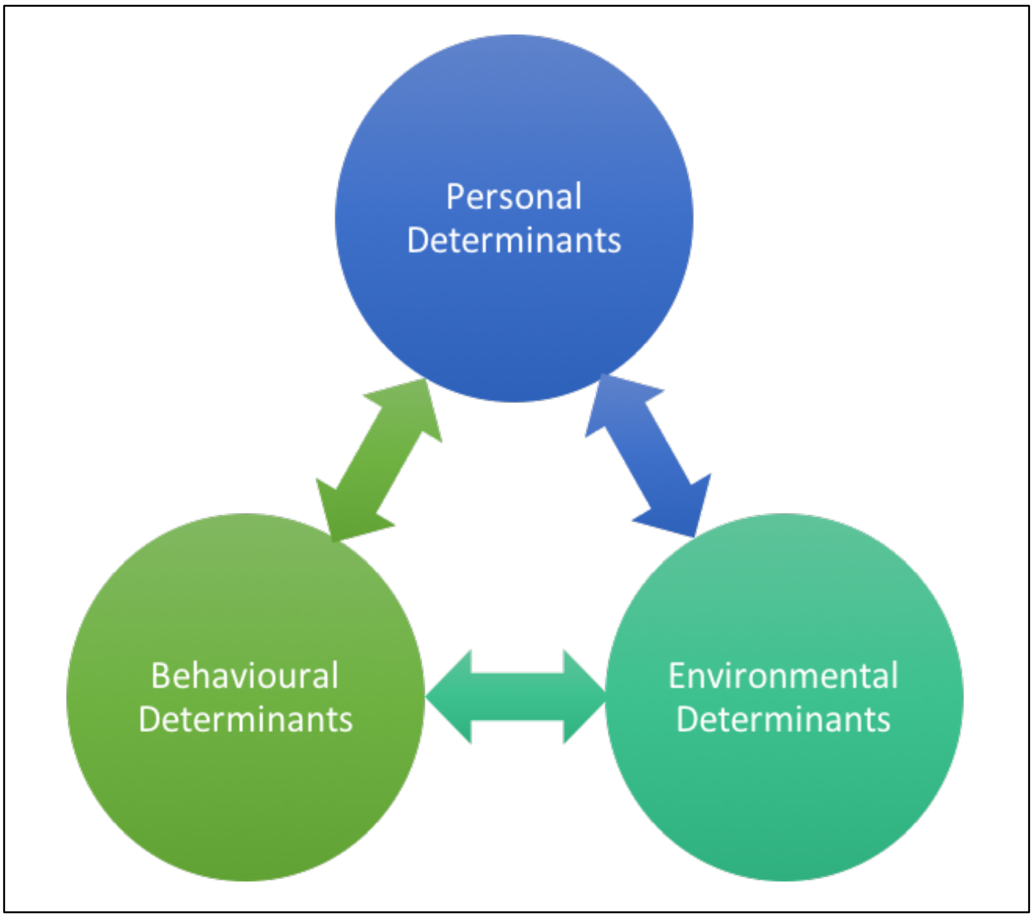

Figure 7 Elements of the triadic structure

3.2.5.1 Elements of the triadic structure

a. Intrapersonal

Intrapersonal factors include characteristics such as self-efficacy, and one can guess that since Social Cognitive Theory is an agent theory, it will prominently emphasise the role of self-efficacy. It also includes cognitive and other personal factors such as personal goal-setting and quality of analytic thinking (Bandura, 1991, p. 267). Forms of agency fall under this factor and Bandura (2012, p. 12) distinguishes between personal and proximal agency. Personal agency involves the conditions over which one has direct control, but some goals can only be achieved with the help of other people and by working together. This agency by proxy[8] is also important for control and is exercised mutually within social groups and environments.

b. Environment

Bandura (2012, p. 11) distinguishes between facets of the environment that influence the other determinants and are in turn influenced by them. These are imposed, selected and constructed environments. An imposed environment is the environment to which a person is delivered and that is given to a person, but Bandura (2012, p. 11) does say that one has some fiddling room within an imposed environment. For the most part, environments are selected and created. The productive potential of the environment must be understood in the light of the following statement by Bandura (2012, p. 12): "… *people create environments that enable them to exercise better control of their lives.*" One should consider this statement against situations such as learned helplessness, where no effort is made to change the environment, or ask to what extent a person is able to change his/her environment in a prison (Bandura, 1977b, p. 196). The latter is a good example of an imposed environment and one must wonder whether people can creatively change this environment to enable efficacy and agency. The same goes for people living in harsh and improvised conditions.

Environment can also be understood not only as a the concrete immediate surroundings, but also as the social network and virtual environment, for instance when people live in virtual social networks on the internet and in social media (Bandura, 2012, p. 12).

c. Behaviour

Behaviour is the third determinant of human functioning. Human functioning is not simply behaviour, but includes conditions, emotions and the like, which influence and are influenced by behaviour or actions. Behaviour is usually regarded as the outward, most observable and deliberate acts of human beings, but human and psychological functioning cannot be restricted to these. Bandura tries to emphasise the fact that human functioning is determined by all three elements, namely behaviour, environment and intrapersonal factors. Of course, behaviour is what we usually want to change: if someone is afraid of spiders it is the obsessive avoidance of spiders that must be changed, but reciprocal determinism indicates that personal feelings of fear and so on also need to be changed. An interesting question that arises is whether acting as if one is not afraid lessens fear, or whether reduced fear strengthens brave behaviour.

[8] Proxy agency: see Bandura (2012, p. 12)

Reciprocal determinism, according to Bandura (1986, 1997; 2012, p. 12), means that the three elements influence each other to enable people to control and change their behaviour and the environment. The ability of people to influence their behaviour and control the environment is an outflow of personal agency (Pajares, 1997). Each of the elements influences the others. For example, the environment can determine behaviour, but reciprocally behaviour can exert an influence on the environment. The same applies to internal personal factors. Factors such as cognitive, affective and biological events and experiences can influence behaviour, but behaviour reciprocally determines internal events (Bandura, 1997, p. 6). A simple example will suffice: If I feel anxious, it could inform my behaviour and cause me to act hesitantly, or if I act confidently, this could eventually determine how I feel. The environment is more than the physical environment I have immediate contact with but also the larger social-cultural context within which I live.

Social Cognitive Theory rejects strict individualism. Individuals never act on their own without being influenced by, or influencing the social environment of which they are part. As Bandura (2006b, p. 165) says, "*Social Cognitive Theory rejects a duality of human agency and a disembodied social structure. Social systems are the product of human activity, and social systems, in turn, help to organize, guide, and regulate human affairs*." However, it must be noted that, whilst Bandura's theory acknowledges the importance of the social dimension, it is not social constructionist (again, not in a holistic sense where something new emerges from the interaction of the parts): he maintains a "*functional consciousness, and a self-identity*" Bandura (2006b, p. 167). The importance of the individual's ability to bring about change and control behaviour and the environments is best illustrated by the emphasis of Bandura (1986) on the crucial role of beliefs and particular self-efficacy beliefs to predict future performance. Indeed, it is not skills, knowledge or even previous achievements that predict future behaviour but these aspects mediated by self-efficacy beliefs (Pajares, 1997).

The next question relates to how agency fits into the plan of triadic reciprocal causation. The model of human functioning clearly shows that three components are required for people to act. How important is the role of agency in this model, and does agency enable us to explain behaviour in the real world? The problem with Bandura's explanations of the various aspects of human functioning is that he tends to illuminate the same issues from different perspectives. On the one hand one has the concept of agency, as discussed above, which seems to be a crucial characteristic of human functioning, and on the other hand, the model of triadic reciprocal determinism needs to account for agency. One could perhaps situate agency within the person, thus as an intrapersonal determinant of human action. However, the brief discussion above pointed out the properties of agency, which are intention, envisaging, action and correction. While action is part of the behavioural component of the triadic model, the cognitive and meta-cognitive aspects are internal aspects and the correction of behaviour and action usually come from both internal and environmental contexts. It might be difficult to map specific concepts on, for instance, the triadic model, but in my opinion Bandura describes the same thing from different aspects. Both agency, as set out above, and the triadic model therefore describe human functioning, but with slight emphasis on a different aspect. In this sense the concept of agency is much more than a descriptive for a unitary "motivating drive": it is also an expression of human functioning from the perspective of the individual while still encompassing the cognitive, behavioural and environmental aspects expressed a bit more prominently in the triadic model. Both agency and the triadic model express causality: the triadic model focuses on where something takes place, whilst agency tells us how it takes place. However, Bandura does not stop here and also incorporates the concept of self-efficacy as an additional point of view regarding the nature of human beings.

Bandura (1995a, p. 2) views self-efficacy as one of the important mechanisms of agency. He defines self-efficacy as "*beliefs in one's capabilities to organize and execute the courses of action required to manage prospective situations.*" Agency is the mechanism by which people affect their own psychological functioning and, as mentioned above, the environment and other people. To explain the causal component of agency, self-efficacy is invoked as a way of describing how people progress from thought to action. Agency was defined above as consisting of the follow acts: *intend, envisage, act and correct,* or as Bandura labels them: intentionality, forethought, self-reactiveness and self-reflectiveness. Self-efficacy stops short of action, so we could probably say that self-efficacy encompasses the first two characteristics of agency, namely, intentionality and forethought (or, as verbs, intend and envisage).

From the following discussion of self-efficacy it should be possible to determine whether this understanding of the relationship between agency and self-efficacy is what Bandura intended. By restricting self-efficacy to the first two characteristics, one acknowledges the fundamental importance of self-efficacy in the causal progression from thought to action, since without the element of self-efficacy nothing will happen. Bandura (1982, pp. 124, 127) regards self-efficacy as the crucial element by means of which one can predict and explain human behaviour, i.e., there is a correlation between levels of self-efficacy and behavioural outcomes.

3.3 Self-efficacy

From the discussion about agency it became apparent that Bandura regards self-efficacy as a crucial mechanism in the causal origin of behaviour. Bandura (2006b, p. 170) is of the opinion that people's development and what they become in life is wholly dependent on efficacy or the belief that they are able to achieve certain goals. In fact, to be human is to strive towards some goal, and the extent to which one moves towards one's goals is determined by the belief that one can achieve those goals. Levels of self-efficacy determine a positive or negative outlook. Bandura (2006b, p. 171) also states that self-efficacy beliefs influence outcome expectancies. In other words, what people believe they can do determines what they believe the outcome of certain actions will be. Pajares (1997) points out that Bandura (1997) introduced self-efficacy[9] as a crucial concept in 1977. The full integration of the concept of self-efficacy within Social Cognitive Theory took place in 1986 with his publication *Social foundations of thought and action: a Social Cognitive Theory* (Bandura, 1986). Almost 10 years later, the social embeddedness of self-efficacy became apparent in Bandura's (1997) discussion of self-efficacy.

3.3.1 Definition of self-efficacy

Self-efficacy can be defined as the belief that one has the capability to do certain things (Bandura, 1977a, p. 194; 1986). According to Bandura (1986), self-efficacy is the most important determining factor of behaviour. It also determines how persistent people will be when faced with obstacles and challenges (Bandura, 2012, p. 13). Bandura (1986, p. 391) defines self-efficacy as follows:

> *Self-efficacy is defined as people's judgement of their capabilities to organize and execute courses of action required to attain designated types of performances. It is concerned not with the skills one has but with judgement of what one can do with whatever skills one possesses.*

One might say that self-efficacy is the belief that one can reach one's goals despite resistance and obstacles. Self-efficacy is therefore a person's belief in his/her capabilities. The first thing that should be noted is that self-efficacy is a *belief.* A belief is not a thing or a concrete construct; it is probably a cognitive state regarding something. Second, as a belief self-efficacy is an expectation directed to the future; in structure, it is similar to intentionality. It is therefore an *awareness of a state of affairs that could be realised in the future*.

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[9] In educational research, self-efficacy featured prominently until the late 1990s. According to Pajares (1997), three areas were investigated. The first area that was explored was the relationship between self-efficacy and major subject choice on a tertiary educational level and in career choice. The second investigated the effect of the self-efficacy beliefs of teachers regarding the way they taught, while the third area of research found evidence that students' self-efficacy was related to motivational and achievement constructs.

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Based on Bandura's definition quoted above, the following can be said: First, self-efficacy is a judgement; thus a cognitive act. It is an evaluation a person makes about his/her ability to accomplish something. What Bandura (1986) calls a judgement in this particular definition is also called a belief by numerous other authors, and later also by Bandura. Bandura (2012, p. 11) also speaks of perceived self-efficacy (PSE). The terms *perceived* and *belief* both refer to the judgment one makes about one's self-efficacy. One should distinguish between perceived self-efficacy and actual levels of self-efficacy. Bandura emphasises the fact that we have a perception of how high or intense our level of self-efficacy is, and it is this belief that influences the effort we will put in and maintain in an attempt to achieve certain outcomes. Self-efficacy is not a belief about skill, but rather a belief about what one is able to do given one's skills under certain conditions (Maddux, 2005, p. 278). I will refer to self-efficacy (SE) as shorthand for self-efficacy beliefs (SEB) or perceived self-efficacy (PSE).

Second, self-efficacy is a judgement or belief about something, in this case about capabilities and not about outcomes. Self-efficacy means "*I believe I can do this particular thing*." Capability refers to the ability or capacity to do something, but it is not a prediction about actual behaviour (Maddux, 2005, p. 278). There is, of course, a strong relationship between believing one can do x and actually doing it, but it should be obvious that (a) one would not try doing things that one does not believe one can do, and (b) sometimes one might overplay one's hand (by failing to accomplish something one believed was possible).

In Bandura's definition above, capability does not refer to any capability, for instance the ability to breathe, but specifically to those *courses of action* that need to be executed to achieve a particular outcome. An example of a course of action is: "*In order to complete the 100 meter dash in less than 11 seconds, I need to be able to run fast enoug*h." The first clause refers to the outcome and the second refers to the capability. However, since "*I need to be able to run fast enoug*h" is not enough to spur me on to try, I need to say, judge or believe that *"I can run fast enough"* in order for the belief to count as a self-efficacy belief.

The example above illustrates the difference between belief and actual skill. I may or may not have the capability to run fast enough to achieve the specific outcome, but according to Bandura, the actual level of skill is not the crucial factor in achieving an outcome. It is the belief that I can do it that counts (Maddux, 2005, p. 336). In the following section self-efficacy will be distinguished from the related constructs.

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3.3.2 Distinguishing self-efficacy from related concepts

In paragraph 3.3.1 above, self-efficacy was defined as a person's belief that he or she can accomplish something specific. Self-efficacy therefore relates to particular tasks. Although unlike other static concepts, such as self-esteem, it is aimed at accomplishing something – it is not an active or agentic construct. In a sense it is a prerequisite for agency, since without an adequate level of self-efficacy a person would not even attempt a certain action.

In other words: self-efficacy is neither a causal attribution nor a reference to self-esteem, but rather a person's belief that he or she can execute certain behaviours or actions to produce a specific outcome (Maddux, 2005, p. 336). Self-efficacy is also not a personality trait. Self-efficacy differs from self-esteem in that it depends on contextual factors and is concerned with a specific goal (Jungert & Rosander, 2010, p. 648).

Self-efficacy must be distinguished from a number of related concepts (Maddux, 2005, p. 278).

a. It is not a perceived skill, which is something like having a skill in producing pottery. Self-efficacy is the belief that I can make pots irrespective of skill (although if I do have the skill, my self-efficacy beliefs will be higher).
b. It is not a prediction of behaviour. Although self-efficacy is a good predictor of related behaviour, it is not in itself a prediction.
c. It is not a causal attribution. When a particular reason can explain someone's behaviour, that reason is a causal attribution for the behaviour (Kelley, 1973). Anything might serve as a causal attribution and such attributions usually form part of a folk psychology or theory of mind (Spunt & Adolphs, 2015). Bandura calls self-efficacy a causal determinant of behaviour (Williams, 2010). Therefore, although self-efficacy can be a causal attribution, it is one of many and usually is not the typical attribution one would make in a folk-psychological context.
d. It is not an intention to behave and, as indicated on page 68, its structure is similar to that of intentionality, i.e., the focus is on a perceived ability to realise something in the future. However, the intention to do something is different from the belief that one is able to do something. Williams (2010, p. 418) equates intentions to willingness to act and thus distinguishes this concept from self-efficacy. However, I do not consider his characterisation of intention to be altogether correct.
e. It is not the intention to obtain a goal. Goal setting and achievement are consciously aimed at achieving a specific result, but one might not feel capable of doing so.
f. It is not self-esteem. Self-esteem can be defined as an judgement or evaluation of one's self (Lafrenière, Bélanger, Sedikides, & Vallerand, 2011). A distinction can also

be drawn between implicit (unconscious) and explicit (conscious) self-esteem. Self-esteem is what I believe about myself and how I feel about this belief. Self-efficacy might contribute to self-esteem if a person is invested in a particular belief (Maddux, 2005, p. 278).

g. It is not a motive (Maddux, 2009). According to Lee, McInerney, Liem, and Ortiga (2010, p. 264), motivation is "an internal state that instigates, directs, and maintains behaviour." The source of sustainable energy for behaviour is not the same as believing one can do something – in the chain of causal events self-efficacy comes before the energy is unleashed. However, self-efficacy can be seen as part of the spark that lights the fire of motivation, or low self-efficacy = low motivation: "As a performance-based measure of perceived capability, self-efficacy differs conceptually and psychometrically from related motivational constructs, such as outcome expectations, self-concept, or locus of control" (Schweizer & Zimmermann, 2000, p. 82).
h. It is not an outcome expectancy. According to Williams (2010), a key aspect of self-efficacy theory is its ability to predict outcome expectancy, which is the expectation that certain behaviours or actions will have the desired outcome. Interestingly Williams (2010) notes that although the causal direction of Social Cognitive Theory is in the direction of outcomes, the expectation that outcomes cannot influence self-efficacy was contradicted by several studies. Williams (2010, p. 418) calls for a re-evaluation of the relationship between self-efficacy and outcome expectancies and expresses the notion that outcome expectancies play a bigger role as a behavioural determinant than Bandura would allow for. The issue of outcome expectancies will be briefly discussed further below.
i. It is not a personality trait. McCrae and Costa (1995) point out that tendencies to behave, think and feel in a certain way are indicative of personality traits and differ from motivational constructs. However, although self-efficacy is not a trait, one can certainly ask whether individuals have efficacious tendencies and therefore efficacious personalities. A person who exhibits learned helplessness (low self-efficacy) certainly has a personality construct expressing this tendency. However, Bandura (2012) points out that self-efficacy is not a unitary construct as one can have low self-efficacy for one activity (e.g. studying), but high self-efficacy for another (e.g. playing rugby). Personality traits are supposed to be relatively stable across activities.

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There are also other related constructs:

a. Resilience: This is an important part of self-efficacy, but it is not the same. High self-efficacy implies that one can persevere despite obstacles. Obviously this is not absolute, since when obstacles become too intense they might be discouraging to such an extent that the desired behaviour is abandoned. Resilience can be seen as “the ability to overcome adversity” (Thomas & Revell, 2016, p. 457).
b. Locus of control: This refers to a person’s belief regarding the amount of control his/her behaviour has to influence the environment. It also refers to the more general belief that a person can or cannot control the outcome of his/her behaviour. Locus of control differs from self-efficacy in that it pertains to the outcome of behaviour, and only to a lesser extent to a person’s ability to perform specific behaviours (Maddux, 1995b, p. 22).
c. Difference between self-efficacy and self-efficacy belief: As indicated above, the correct use of the construct is self-efficacy belief because of the primary role played by belief.
d. Optimism: This is the belief that good things will happen (Carver, Scheier, & Segerstrom, 2010), i.e., the expectancy about positive outcomes in the future (Carver & Scheier, 2014, p. 293). By distinguishing between optimistic self-efficacy and realistic self-efficacy, Bandura indicates that the optimistic person will prevail much longer than a realistic person in his/her effort to achieve an outcome (Klassen, 2004, p. 206). It is interesting to note that Carver and Scheier (2014, p. 293) relate optimism to self-efficacy, attributional style and hope. To illustrate the difference between self-efficacy and optimism, one can regard optimism about a particular outcome as the result of one’s belief that one can do what is required to achieve that outcome (Carver & Scheier, 2014). However, optimism is more than a situational expectancy; Carver and Scheier (2014) regard optimism as a dispositional construct, thus applicable in diverse situations and stable over time.
e. Agency: This was discussed in paragraph 3.2.4 above and was explained as the umbrella construct for self-efficacy.
f. Goal orientation: This refers to the goals adopted by individuals in achievement situations. It can also be the mental framework that determines how individuals interpret and respond to achievement situations (Culbertson, Smith and Leiva, 2011, p. 116). Self-efficacy has a goal component and therefore overlaps only partly or very narrowly with goal achievement.

3.3.4 The relationship between self-efficacy and outcomes

The relevant literature reveals considerable confusion regarding the difference between self-efficacy and outcome expectations. As noted above, Bandura start off with the outcome expectancy construct and its influence on behaviour. An outcome expectancy is the judgement one makes about the expected results of one's actions or behaviour (Bandura, 1986, p. 391). Outcome expectancy is not a clear construct and Kirsch (1995) shows that outcome expectancy can be defined in more than one way. He mentions two primary definitions, the first of which he calls a "*means-ends belief*", which can be defined as follows: "An outcome expectancy is a subjective probability that a particular behaviour, if performed by someone at a given level of competence, will be followed by a particular outcome" (Kirsch, 1995, p. 333). Compare Bandura's (1997, p. 193) definition: "An outcome expectancy is defined as a person's estimate that a given behavior will lead to certain outcomes." Maddux (1995a, p. 15) provides the following formulation: "An outcome expectancy is the belief that a behavior will produce an outcome or result, as opposed to a self-efficacy expectancy, which is a belief that one can perform the behavior that might produce the outcome."

The second definition is of "*a personal outcome expectancy*", which is defined as follows: "An outcome expectancy is a person's subjective probability that his or her performance of a behaviour will be followed by a particular outcome" (Kirsch, 1995, p. 333). There is a natural relationship between self-efficacy and expectancies, more specifically outcome expectancies. According to Kirsch (1995, p. 331), "*self-efficacy is a judgement about personal capabilities that is intimately tied to expectancies about the outcome of contemplated actions.*" The distinction between self-efficacy and outcome expectancies was a valuable theoretical contribution in the history of the development of the constructs (Kirsch, 1995).

Several researchers have indicated that self-efficacy predicts behavioural outcomes (Kirsch, 1995). According to Bandura (1977a), self-efficacy predicts the following:

a. Choosing behavioural activities
b. Effort used on the activities
c. Persistence despite obstacles
d. Actual performance

While a number of authors agree that self-efficacy relates to particular outcome behaviours, it is important to understand why this is so and to identify the mechanisms involved (Kirsch, 1995, p. 332).

The abovementioned distinction between means-ends beliefs and personal outcome expectancies can be graphically illustrated on the basis of empirical studies. Kirsch (1995, p. 333) points out that no logical relationship exists between the differentiated constructs, but that the relationships that do exist need to be empirically investigated. The difference between means-ends beliefs and personal outcome expectancies can be illustrated as follows: If I believe that it is possible for an 80 kg man to lift at least 40 kg (means-ends belief), it does not follow that I believe that I, weighing 80 kg, will be able to do this (personal outcome expectancy). However, even if I believe that I can lift a 40-kg weight, it does not mean that I am going to attempt to do it!

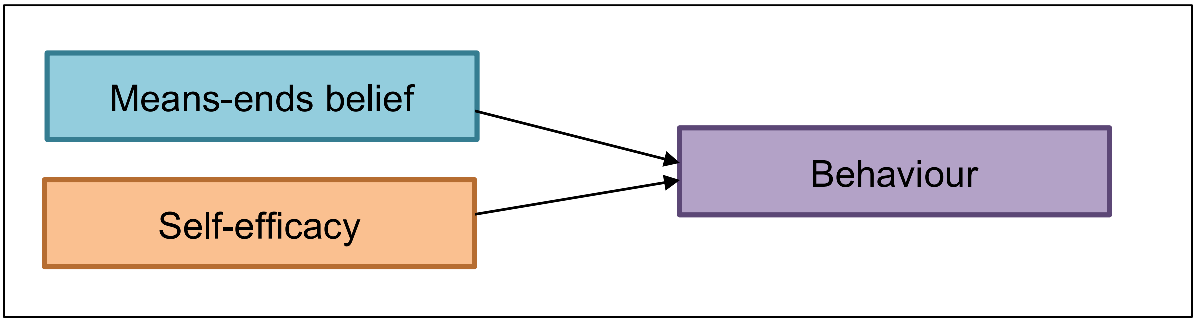

Figure 8 The relationship between self-efficacy and means-ends beliefs as determinants of outcome behaviour (Adapted from Kirsch, 1995, p. 334)

In Figure 8 the relationship between self-efficacy and means-ends beliefs are depicted as the determinants of outcome behaviour. This is how (Bandura, 1977a), according to Kirsch (1995), initially conceptualised the relationship between outcome expectancies, self-efficacy and outcomes.

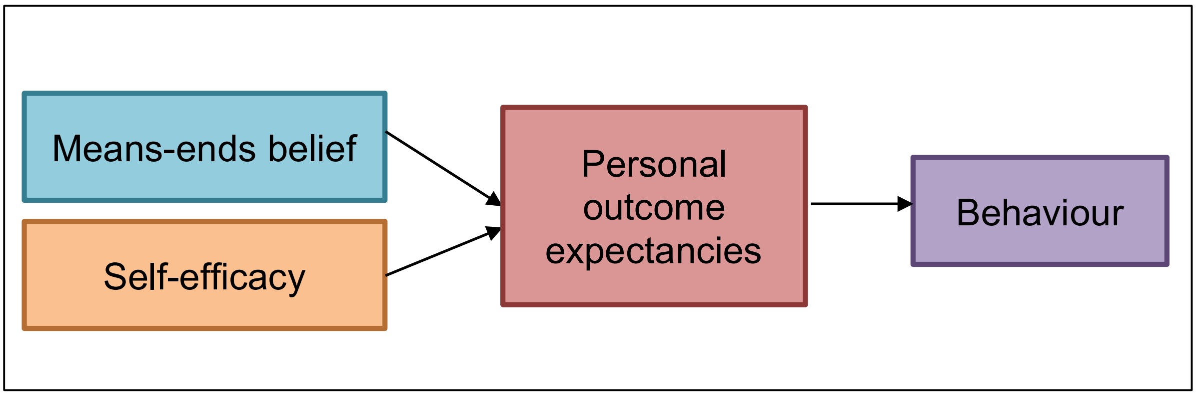

Figure 9 Personal outcome expectancies as mediators of the effects of means-ends beliefs and self-efficacy on achievement behaviour (Adapted from Kirsch, 1995, p. 334).

Kirsch (1995) relationship model, as depicted in Figure 9, shows that personal outcome expectancies function as a mediator between both means-ends beliefs and self-efficacy and behavioural outcome. This model implies that personal outcome expectancies are directly related to behaviour (and behaviour is responsible for outcomes). The model also shows that both self-efficacy and means-ends beliefs are related to, or determine personal outcome expectancies. It makes sense that means-ends beliefs will relate to outcome expectancies. As stated in the example above: I must first believe that it possible for a person who weighs 80 kg to lift a weight of 40 kg before I can even consider that I might be able to do this! Self-efficacy, or the sense of being able to do something, thus informs or determines personal outcome expectancies along with means-ends beliefs.

Even though Williams (2010) maintains that the way Bandura conceptualised the causal path, namely self-efficacy, outcome expectancy, behaviour and outcomes, precludes the possibility of outcome expectancy determining self-efficacy beliefs. Although this debate subsided over the years, Williams (2010) points out the fundamental contradiction in Bandura's conceptualisation, which is that if self-efficacy determines outcome expectancy, but the latter does not determine the former, despite acknowledging that this is possible, then Bandura committed an error of logic. Although Bandura is aware of the fact that outcome expectancy can influence self-efficacy, this does not deter him from maintaining his original position, which is that outcome expectancies cannot influence self-efficacy.

While Williams (2010, p. 417) maintains that self-efficacy is an excellent predictor of behaviour, Pinquart, Juang, and Silbereisen (2003, pp. 331-332) provide an example of the converse. Within this analysis, efficacy and outcome expectations are distinguished, as shown schematically in (Figure 10). An outcome expectancy is defined here as a person's estimate that a given behavior will lead to certain outcomes. An efficacy expectation is the conviction that one can successfully execute the behavior required to produce the outcomes. Outcome and efficacy expectations are differentiated because individuals can come to believe that a particular course of action will produce certain outcomes, but question whether they can perform those actions (Bandura, 1977b, p. 79).

Bandura (1977a, pp. 204-205) uses learned helplessness as an example to illustrate the difference between the two concepts. Learned helplessness shows that the environment is a determining factor in facilitating ineffectual expectancies about outcomes despite high self-efficacy (i.e., a belief that under normal circumstances one can execute actions that will have specific outcomes). It thus implies that the environment impacts significantly on the realisation of behaviour. Figure 10 shows how Bandura (1977b, p. 79) conceptualises the distinction. The viewpoint expressed in Figure 10 is important and is probably partly to blame for the confusion regarding the causal order of events. Remember that Williams argues for outcome expectancies influencing efficacy (and probably vice versa), which means that in the figure, outcome expectancies need to be moved to before the behavioural component. However, Bandura locates self-efficacy and outcome expectancy in subsequent positions, i.e., after the course of events has been run. In this regard, it would be preferable to have something similar to a path diagram that expresses the expected antecedent order of events, which means that both self-efficacy and outcome expectancy play a role in effecting behaviour. Simply put, Bandura's diagram locates outcome expectancy after behaviour, which does not make sense in a causal chain of events: expectancy implies a future-directed judgment about a state of affairs, i.e., what would happen if I have behaved in a certain way, thus locating outcome expectancy before behaviour in Figure 10.

Where should outcome expectancy be located in the diagram? Looking at Bandura's revised diagram Bandura (2012, p. 14), depicted in Figure 11, it is clear that outcome expectancy was positioned as a determinant of behaviour. Bandura regards self-efficacy as a direct determinant of behaviour, but also as influencing outcome expectancy. Despite the somewhat greater clarity, this does not address the problem Williams refers to, namely that outcome expectancy can also influence self-efficacy. To give an example: If one believes that a person of 40 kg cannot lift a weight of 50 kg or more, then certainly I, weighing 40 kg, would not be able to do this. Thus, with regard to how they influence behaviour (in this case not acting), outcome expectancy should come before self-efficacy.

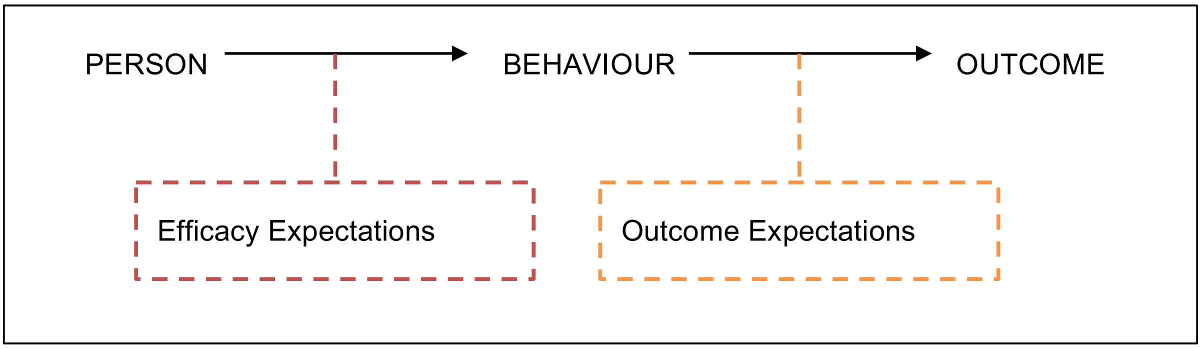

Figure 10 Graphic representation of various expectations

To summarise: If self-efficacy is the belief that one can do something, a natural consequence is that that this particular belief ought to lead one to expect a particular outcome. "I believe that I can lift this weight" therefore implies some relationship between this assumption and the actual lifting of the weight or the outcome. If I believe that I can lift this weight I should usually be able to do so. From this example, it should be apparent that my belief in my ability must be distinguished from my actual achievement of certain outcomes. This is of course the first issue in the relationship between outcomes and beliefs: although the implication of expecting a certain outcome is present in the belief about one's ability, many things can confound this relationship. For instance, I might overestimate my ability despite my strong conviction that I will be able to do something! Thus, notwithstanding high self-efficacy, a particular outcome need not follow. Hackett (1985, p. 49) refers to her and Betz's previous study, conducted in 1984, during which their research confirmed that mathematics-related self-efficacy is a stronger predictor of math-related career choices than ability. According to Bandura (1986, p. 391), self-efficacy is a better determinant of performance than basic skills. However, the combination between self-efficacy and skills is required to function optimally.

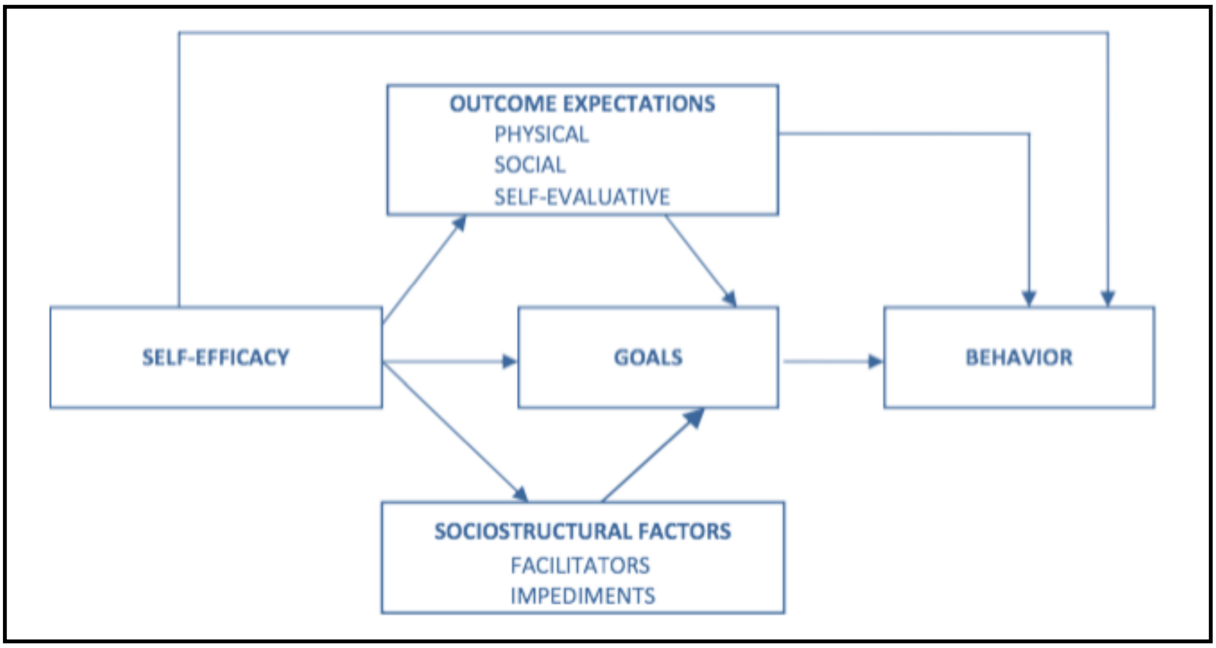

Figure 11 Structural paths and the placement of outcome expectations (Bandura, 2012, p. 14)

To return to the point of outcome expectancy, the distinction between the two concepts in this study lies in difference between can do and need to do: a) outcome expectancy: In order to achieve y, I need to do x; b) self-efficacy: I can do x to achieve y.

3.3.5 Effects of self-efficacy

Bandura (2012, p. 13) explains the effects of self-efficacy as effects on the quality of human functioning. The quality of functioning is influenced by cognitive, affective, motivational and decisional processes.

3.3.5.1 Cognitive processes: Negative / positive style of thinking

A person's style of thinking is influenced by self-efficacy and can be either optimistic or pessimistic. This reminds one of the body of literature dealing with learned helplessness and enabling thinking. The way one approaches situations and thinks about events, oneself and others can be either optimistic or pessimistic. This relates to work done on optimism/pessimism, and the measurement of life orientation by Carver and Scheier (2002). Bandura (2012, p. 13) states that thinking can be either self-enabling or self-debilitating, which corresponds closely with an optimistic or pessimistic outlook (Bandura, 2015, p. 1029).

3.3.5.2 Affective processes

Self-efficacy affects emotion and affective states. One important example is the ability to self-regulate emotions when faced with difficulties in the pursuit of achieving goals. One might call this process "coping", which means that coping with stress and uncertain situation depends on self-efficacy. This coping may be seen as an emotion protective factor: susceptibility to stress, depression and feelings of failure can be countered by high levels of self-efficacy (Trouillet, Gana, Lourel, & Fort, 2009, p. 358). Bandura (1995b, p. 26) maintains that it "is not stressful life conditions per se but the perceived inability to manage them that produces the detrimental biological effects." He thus fully recognises the well-documented effects of stress/adversity on biological processes, such as surpassing immune responses and so on, but he postulates a crucial moderating variable: perceived coping is crucial for controlling and managing stress and its detrimental effects. Coping in this sense is seen as self-efficacy or the ability to control the environmental stressors.

3.3.5.3 Motivational processes

The role played by self-efficacy in motivational processes is important for keeping up efforts when encountering difficulties or opposition. In a sense, then, resilience determines the extent of motivation. If one maintains a high belief in one's ability to do something, this serves as motivation to continue trying or making an effort. Bandura also mentions the importance of maintaining goals when faced with adversity (Locke, 1996, p. 120). The level of motivation naturally determines the strength of the goals that have been set.

3.3.5.4 Decisional processes

Bandura (2012, p. 13) extends the effects of strong self-efficacy to decisional processes that have long-term effects on life trajectories (Bandura, 1995b). According to Maddux (2005, p. 335), self-efficacy is critical in psychological health and when self-guided behavioural change strategies are implemented.

3.3.6 Types of self-efficacy

From the discussion above it ought to be clear that self-efficacy has many nuances and must be distinguished from other concepts, such as optimism, resilience and so on. However, if we accept the definition of self-efficacy as "a belief that one can…", then the one variable aspect is the object of the belief. The question is whether one can make a distinction between a belief that one can do mathematics and the belief that one can learn to ride a bike. Are they the same, or can self-efficacy be transferred between domain competencies? Can one speak of a person as a generally self-efficacious person, or does his/her self-efficacy apply to only certain domains? Some reflection on the matter will reveal that competencies are not equally distributed in individuals: I might be a good bike rider but be bad at maths, so I might have different beliefs about my abilities. I might also dream of attempting motorcycle racing because I am a skilled cyclist. It should be clear that on conceptual grounds a distinction can be made between domain-specific self-efficacies. Bandura (2012, p. 17) states that when measuring self-efficacy, the "types of self-efficacy that are relevant will depend on the sphere of activity." By extending this line of thought one might question even the validity of speaking about a general sense of self-efficacy; it is merely another domain-type self-efficacy, albeit a conglomeration of specific self-efficacies. Let's call this g-self-efficacy. It merely means that a person believes that he or she can do many things instead of only the three things he or she normally does. However, our reasoning precludes us from allowing g-self-efficacy to apply to everyone. Some people might be multiskilled and have a sense of general self-efficacy that others lack.

In the literature, though, a distinction is made between general or generic type self-efficacy and specific types of self-efficacy (Abele & Spurk, 2009, p. 54; Argyropoulou, Sidiropoulou-Dimakakou, & Besevegis, 2007, p. 318; Klassen, 2004, p. 222). This distinction will be examined in the following section.

3.3.6.1 General self-efficacy

Argyropoulou et al. (2007, p. 318) maintain that "general self-efficacy aims at a broad and stable sense of personal competence to deal effectively with a variety of stressful situations." Koumoundourou, Kounenou, and Siavara (2012, p. 271) provide a somewhat broader definition of general self-efficacy as the perceived ability to complete a set of behaviours (Latham, 2007, p. 140). Argyropoulou et al. (2007) go on to define career indecision as a stressful situation against which generalised self-efficacy can provide a buffer. Their study involving students in the process of making career choices showed that career indecision relates somewhat to generalised self-efficacy, although they identified factors such as exposure to sufficient information as influencing indecision and self-efficacy. In other words,

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they found that a person with sufficient information and some experience would be more decisive and thus exhibit more stringent generalised self-efficacy.

3.3.6.2 Specific self-efficacy

In the context of substance abuse and recovery, Marlatt, Baer, and Quigley (1995) describe five types of self-efficacy, including recovery self-efficacy and abstinence self-efficacy. These reflect the activities under examination, but Bandura (2012, p. 17) warns against making an activity too narrow and shows a preference for measuring self-efficacy with broader and narrower domains (called competency domains) encompassing not a single task, but a range of tasks. Thus, bike-riding self-efficacy might be too narrow a view of task self-efficacy. Riding capability or competency would include different modes of riding things ranging from bicycles to roller-skates, although a person's competency in riding different things might vary. The example Bandura (2012, p. 17) uses is that of intelligence: an IQ test consists of various sub-dimensions (mental rotation, numerical, etc.), but we speak of IQ on a particular level of reduction. Intelligence is not the one item of, for instance, numerical ability Although one might accept Bandura's point on the level of reduction, which warns against defining self-efficacy too narrowly (for instance based on my ability to open a jam jar), the specific reduction level at which one should stop can be difficult to pinpoint. In fact, the way Bandura formulates the problem of general and specific self-efficacy is a typical psychometric problem described in terms of multidimensionality. At a particular level of reduction any construct can be viewed as unidimensional, but at another it may become a multidimensional construct (as IQ measurement illustrates).

Bandura (2012, p. 36) quotes empirical studies that show that domain-specific self-efficacy cannot be used as a generic concept: one type of self-efficacy does not apply in another domain in accordance with the conceptual analysis suggested above. Thus, empirically, one type of self-efficacy cannot predict ability and behaviour in other domains.

Different specialised forms of self-efficacy can be described: *task self-efficacy* involves the belief that one can accomplish target behaviour and perform targeted acts successfully; *operational self-efficacy* is the ability to adapt to changing or contingent events; and *coping self-efficacy* is the belief that it is possible to prevent, control or cope with potential difficulties (Maddux, 1995b, p. 330). Self-efficacy can also be combined with specific domains, such as "career", to form a career-related efficacy as a construct that will be applicable in a specific domain. One can thus speak of career, occupational or behavioural agency or self-efficacy, which denotes the congruency between a person's capability and career development (Ancis & Phillips, 1996; Rivera, Chen, Flores, Blumberg, & Ponterotto, 2007; Sullivan & Mahalik,

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2000). Thus, one is more likely to choose a career that one believes one is capable of doing or mastering. This means that a woman will choose a career in line with her career self-efficacy beliefs and avoid those in which her self-efficacy beliefs are low (Ancis & Phillips, 1996). O'Brien (2003, p. 110) defines career self-efficacy as "confidence in one's ability to manage career development and work-related tasks." Occupational self-efficacy deals with self-efficacy as a domain-specific construct (Rigotti, Schyns, & Mohr, 2008, p. 239). It refers to the competence that a person feels concerning the ability to successfully fulfil the tasks involved in his or her job.

3.3.7 Self-efficacy dimensions

The above discussion might be clarified by Bandura's (1978, p. 142) conceptualisation of self-efficacy as a construct that varies on three dimensions, namely, level (magnitude), strength and generality (Bandura, 1977b, pp. 84-85; Lent & Hackett, 1987, p. 348) .

The level of magnitude of self-efficacy refers to how difficult a person regards the tasks he/she is able to perform. A distinction can be made between easy vs difficult and a measuring instrument could be used that requires people to indicate the level of ease with which they will be able to perform a specific task. More concretely, one could specify a series of actions deemed less and more difficult, which a person could be asked to endorse (Maddux, 1995a, p. 9). The series of steps that a person suffering from arachnophobia can execute in their order of difficulty is a good example [see Bandura's actual experiments in (1978, pp. 146-147; 1982)].

Strength refers to how much confidence one has in one's ability to do a task. Maddux (1995a, p. 9) calls it the level of resoluteness to do something. A distinction can be made between low and high confidence. It might be assumed that strength and level relate to each other: if a task is easy to accomplish, one might supposedly also have high confidence in one's ability to complete the task. This means that if a person has low confidence, self-efficacy will be easily influenced by, for instance, a negative experience such as failing at a particular task, and a person with a high level of confidence or rather strong self-efficacy beliefs will be more resilient in the face of obstacles or negative experiences. According to Maddux (1995a, p. 9), this persistence in the face of obstacles defines strength of self-efficacy.

Finally, generality refers to the range of activities that one feels confident to be able to complete. A person with high levels of generalised self-efficacy might feel empowered with a range of activities, while someone with a narrow range might feel competent in only a few or narrow activities (see discussion above). Maddux (1995a, p. 9) points out that the carrying over of feelings of self-efficacy from one context to another lies at the core of this dimension.

Based on their magnitude, strength and generality, all three these dimensions can be strongly operationalised in self-efficacy measurements by varying items.

3.3.8 Self-efficacy sources

Bandura (1978, pp. 142-148) maintains that self-efficacy beliefs are fed from four sources: mastery experiences, vicarious experiences, supportive experiences and emotional experiences (Bandura, 1977a).

3.3.8.1 Mastery experiences

Mastery experiences refer to activities and successes already mastered. Experiences of failure might lower levels of self-efficacy, whilst successive mastery experiences could raise self-efficacy. Bandura hypothesises that high self-efficacy resulting from a number of mastery experiences makes a person more resilient to subsequent failures. The frequency and timing of failures play a crucial role in the process of trying to master activities (Bandura, 1978, p. 143). A high frequency of failures at the beginning of mastery activities would probably reduce self-efficacy. Some failures later on could harden resolve in the light of high self-efficacy. It is probably important to experience a number of early successes in performing a specific activity.

3.3.8.2 Vicarious experiences

Vicarious experiences refer to seeing something done by someone else (also called social modelling) (Bandura, 2012, p. 13). Within the context of treatment for phobias, seeing somebody doing something one thought would be difficult might have an enabling effect on one's own self-efficacy (keeping in mind that aversive reactions might also be vicariously triggered!). While Bandura (1978, p. 145) includes concrete and imaginal[10] experiences under vicarious experiences, Maddux (2002) distinguishes between imaginal and vicarious experiences, thus forming a fifth source of self-efficacy knowledge. The first refers to a person's imagining of a successful act or of a role model doing something, and the second to observing role models and successful behaviours. It is interesting to note that literature is

[10] (Maddux, 1995a, pp. 10-11) added another source of self-efficacy to the above-mentioned sources given by Bandura, namely, imaginal experiences (Maddux (2002, p. 337). Imaginal experiences refer to people's ability to visualise situations and events. They can also visualise their behaviour, emotional reactions and possible effects within events. They thus have the ability to predict or project possible actions into the future. Such visualisations can of course be the results of vicarious or personal experiences.

replete with examples of role models for various situations and contexts. Colloquially, setting a bad example by smoking (or whatever) is part of the belief of the effect role models have. Thus, the beneficial effect of role models is built upon this idea of vicarious experiences as a source of self-efficacy.

Bandura (1978, p. 145) does not regard vicarious experiences as being as strong as enactive mastery experiences and maintains that the aforementioned are more susceptible to change and fluctuation. First, modelling experiences have an effective impact if a person sees another struggling to succeed, i.e., making a real effort to execute some action. Bandura uses the example of a phobic seeing another really making a strenuous effort to avoid a particular action, rather than watching, for instance, non-phobic models glibly holding spiders! Second, clear outcomes of actions by others have more impact than ambitious results, and third, seeing different people succeeding at the same action also has a greater impact on self-efficacy.

3.3.8.3 Verbal persuasion

Supportive experiences, or verbal/social persuasion, entail verbal and personal support for someone embarking on an activity (Bandura, 2012, p. 13). See how Bandura (1978, p. 145) formulates the role of verbal persuasion:

> *People are led, through suggestion, into believing they can cope successfully with what has overwhelmed them in the past. Efficacy expectations induced in this manner are also likely to be weaker than those arising from one's own accomplishments because they do not provide an authentic experiential base for them.*

Bandura clearly underestimates the effect of verbal suggestion as opposed to mastery experiences. Research has in more than one context demonstrated the role played by beliefs in behaviour, regardless of the source. In fact, one can do no better than point to the strength of the placebo effect on all kinds of behaviour. However, the point is that verbal persuasion and supportive experience are probably crucial and very powerful mechanisms in influencing self-efficacy; the strength of the so-called talking cure of psychology rests upon this assumption. Maddux (2002, p. 338) echoes the sentiment that verbal persuasion is not as effective as mastery experiences.

Bandura (1978, p. 146) does point out, though, that just telling people stuff will not make them believe it. In order for verbal information to have an effect it has to be believed, so the "persuasion" part is one of the prerequisites. Trying to convince people of something that contradicts their previous experience is also difficult (Bandura, 1986). Bandura (1978, p. 146) believes that verbal persuasion has a stronger effect on outcome expectancies than on self-efficacy expectancies[11] and limits the efficacy of verbal persuasion to its combination with performance aids, i.e., performance aids will be more effective when combined with verbal support.

Verbal encouragement within particular significant relationships is important for enhancing self-concept and self-efficacy. An important finding in later research was that verbal persuasion has a greater effect if it is received within a significant relationship, such as a relationship with a peer, a parent or a teacher (Zeldin & Pajares, 2000). Maddux (2002:338) suggests that the efficacy of verbal persuasion depends on the trustworthiness, attractiveness and "expertness" of the source, which in a way supports the role of the significance of the source, but adds interesting twists: marketing research on persuasion shows that attractiveness and authority might persuade, and the same applies to the influencing of self-efficacy beliefs. It is also easier to discourage than to encourage a person, thus decreasing self-efficacy. In other words, verbally discouraging people would lead to them tending to avoid the activities involved because they have doubts about whether they have the ability to complete them (Bandura, 1986).

The following important observation is made by Bandura (2012, p. 13) regarding social persuasion: "Individuals are encouraged to measure success by self-improvement, rather than by triumphs over others." In fact, this remark reveals a great deal about how Bandura's views progressed and developed over the years from where he had started out, with self-efficacy on the border between behaviourism and Social Cognitive Theory. The support he finds in the research about the management of phobic responses is referred to. The interpretation of social support, which tellingly was first called verbal persuasion, deepened over the years as is illustrated above. The above quote encapsulates years of research about motivational processes that have beneficial effects on humans. Here the researcher refer to the work of Carol Dweck and others (Dweck, 1986; Dweck & Leggett, 1988; Elliott & Dweck, 1988; Grant & Dweck, 2003; Heyman & Dweck, 1992), who started their theorising with the paradigmatic experiment of learned helplessness (Diener & Dweck, 1980). Without dealing with the progression of this line of research it suffices to say that motivational goals or achievement

[11] What does this statement by Bandura imply? It has become clear from previous discussions that outcome needs to be distinguished from self-efficacy expectancies. Each may influence the other, depending on the environment or context, therefore the distinction is rather difficult, but I suppose that the way in which Bandura defines it the distinction makes sense.

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motivation can be explicated as a combination between approach vs avoidance processes and goals, and growth vs performance mind-sets (Maree & Maree, 2013).

Social/verbal support should therefore be more effective if it focuses on enhancing a growth mind-set, rather than a competitive or performance-based one. Research is rather clear on the benefits of the efficacy of growth-approach motivation as opposed to avoidance goals and competitive goals. Performance-approach goals can of course also be motivational and enhancing, and need not be negative in certain contexts; one expects people who are performance-approach oriented to have high levels of self-efficacy even though empirically no or low correlations between the two constructs were found (Usher & Pajares, 2009, p. 97).

3.3.8.4 Physiological and emotional sources

Emotional and physiological arousal refers to the physiological and emotional states that accompany actions and behaviour. However, merely thinking about stressful situations can cause negative emotional and physiological responses that can increase and exceed normal stress-related responses (Bandura, 1978, p. 146). If a person undertakes an activity that causes him or her to experience feelings of anxiety, stress or fear, it can be interpreted as impending failure and subsequent loss of feelings of self-efficacy. However, if the person undertaking such an activity feels confident and does not experience adverse responses (for instance when experiencing flow), the lack of negative feelings and physiological reactions can be associated with success and will result in increase of feelings of self-efficacy (Bandura, 1986). In the case of phobics, Bandura (1978, pp. 146-147) regards the control of the negative physio-emotional arousal feedback as crucial for managing the negative responses. The ability to control reactions to threatening situations and environments could enhance feelings of self-efficacy. Maddux (1995a, pp. 11-12) views physiological arousal and emotional experiences as separate sources of self-efficacy. If these two sources are regarded as separate and imaginal experience is added, the number of sources for self-efficacy amounts to six, even though Bandura acknowledges only the original four (Bandura, 2012, p. 13; Maddux, 1995a, p. 10).

3.3.8.5 Agency and self-efficacy

The concepts self-efficacy and outcome expectancies play a crucial role in social cognitive career theory (SCCT) (see paragraph 3.5 below) (Lent & Brown, 1996; Luzzo, 1994, p. 5). Bandura's work influenced the domain of career choice and development to such an extent that it currently provides an influential model of career behaviour, although by no means the only one.

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Social cognitive career theory offers a substantial theoretical grounding of factors that contribute towards women's professional careers (Yeagley, Subich, & Tokar, 2010, p. 31). Yeagley et al. (2010, p. 31) refer to several studies that used the SCCT as their theoretical premise for the exploration of women's leadership positions in "non-traditional" careers. A high score on self-efficacy was associated with positive outcome expectations.

3.4 Career development

In order to situate the perspective taken in this thesis, it is important to provide a brief overview of career development theories in general and to indicate where the investigation of self-efficacy and Social Cognitive Theory fits in. As discussed below, the focus is very much on the model called Social Cognitive Career Theory (SCCT), which in the overview below falls within social cognitive theories in general. In their discussion of vocational research trends from 2007 to 2014, Brown and Lent (2016, p. 542) distinguish between person-environment fit theories and the SCCT models which, according to them, dominated the field to a large extent. Constructionist theories, or career constructionist theories, which are also discussed below, have also been popular (Brown & Lent, 2016; Maree, 2010).

Person-environment-fit theories tellingly focus on the match of personal characteristics, such as interests and abilities, to what is expected or required in the work environment (Brown & Lent, 2016, p. 542). According to Brown and Lent (2016, p. 542), "*SCCT focuses on the roles of person characteristics (e.g. self-efficacy beliefs, outcome expectations, goals) and contextual factors (e.g. supports, barriers) in educational and work interest development, choice making, satisfaction, and performance.*" Brown and Lent (2016) state that these two sets of theories were the most salient in a literature overview of the following journals: *Career Development Quarterly, Journal of Career Assessment, Journal of Career Development, Journal of Vocational Behaviour, Journal of Counselling Psychology* and *The Counselling Psychologist*.

Career theories are indeed much broader than the three groups mentioned above. The career theoretical landscape is clarified by a brief and helpful overview provided by Zunker (2006), who distinguishes between the following groups of theories: trait-oriented theories, social learning and cognitive theories, developmental theories and person-in-environment theories. These groups of theories will be discussed in the following sections.

3.4.1 Trait-oriented theories

There are three trait-orientated approaches. They are trait and factor theories, person-environment-correspondence (PEC) counselling and Holland's RIASEC theory. Amongst these, trait and factor theories are important.

3.4.1.1 Trait and factor theories

These theories focused on the match between the traits of a person and the characteristics of a particular occupation, thus the measuring and matching of job descriptions and psychological characteristics were important. These are among the earliest theories on occupational development and go back to the early 1900s (Zunker, 2006). Psychometrics played a fundamental role and actually gave impetus to the development of a large body of vocational-interest questionnaires.

3.4.1.2 Person-environment-correspondence (PEC) counselling

Lofquist and Dawis (1991) developed the PEC to emphasise the interaction between work and a number of psychological and other variables. They emphasise the fit between one's work personality and the job environment, as well as the needs that work fulfils. The relationship between job satisfaction and issues such as eventual performance, work adjustment, performance ability and so on is stressed (Zunker, 2006, p. 28).

3.4.1.3 Holland's RIASEC theory

A last important theory that played a significant role in career development studies is John Holland's typology expressed as realistic, investigative, artistic, social, enterprising or conventional (RIASEC), which characterises the work environment and the individual's personal style. This theory and approach has at its core the self-knowledge of the individual and information about the career (Zunker, 2006, p. 35). Thus, with insight into these areas a person is better able to make an informed career choice.

The fundamental approach of trait-based theories is to match interest, personality and skill with a career and career environment. As can be seen, this approach is extensively psychometrically based and a large number of related inventories and instruments have been developed. Zunker (2006, p. 38) suggests that an issue that should be addressed by trait-theories is the changing career landscape. People no longer tend to have lifelong careers and are more inclined to change the course of their careers often during their lifespans. Consequently it has become essential to cater for multiple work and career transitions.

3.4.2 Social learning and cognitive theories

These theories focus explicitly on the development of career possibilities and change over a long period, usually a lifetime. A number of issues are thought to influence career choice and development, for example the social environment that a person is exposed to, the decisions made based on learning experiences, and skills that may be acquired or learned over a period of time. Thus even contextual experiences in various environments influence a person's choices, and career choice is seen to be influenced by a combination of emotional and cognitive factors. Emphasis is placed on personal responsibility, agency and the ability to overcome barriers (Ancis & Phillips, 1996; Rivera et al., 2007; Sullivan & Mahalik, 2000; Zunker, 2006, p. 38). Learning is therefore important, especially cognitive insight into circumstances, barriers and appropriate decisions: "Discovering and unlearning faulty beliefs about career choice and multiple life roles is a major objective of these theories" (Zunker, 2006, p. 38).

3.4.2.1 Learning theory of career counselling (LTCC) (Krumboltz)

Krumboltz, Becker-Haven, and Burnett (1979) developed the LTCC in collaboration with other researchers. This theory focuses on four aspects: (a) genetic endowments and special abilities; (b) environmental conditions and events; (c) learning experiences; and (d) task approach skills (Zunker, 2006, p. 39). These four factors place limits on career possibilities and choices. For instance, genetic endowments and special abilities can either make more or fewer careers available, and poor eye-hand coordination would immediately exclude a number of careers. The same applies to environmental conditions: a change in environmental conditions would limit a person's possibilities. Zunker (2006, p. 38) gives the example of a drought, which would rule out farming as an immediate viable occupation. Learning experiences within certain situations influence what one will do and how one will do it. Zunker (2006, p. 39) explicitly states that certain experiences can reinforce or discourage choices. This type of learning is called instrumental learning. However, associative learning also plays a role in decision making. If, for example, a person has any preconceived ideas, such as that all taxi drivers are thieves, such ideas will influence career decisions.

It is important to note that learning and exposure reinforce whatever preferences one has for a particular career. The quality of decisions is informed by and based on such learning experiences, but a person making a career choice can still be misinformed about the particular career. Certainty is thus not a guarantee for career success. The career counsellor should therefore ensure the availability of information, exposure and assistance with learning. Whatever skills are possessed or learned will influence a person's career choices (Zunker, 2006, p. 39).

3.4.2.2 Cognitive information-processing theory (CIP)

Zunker (2006, p. 44) provides ten assumptions of CIP for career development. They are: a) affective and cognitive processes interact to enable career choice; thus, affective aspects are incorporated in the process; b) career decision making is a problem-solving activity; c) the quality of decision making depends on the quality of information and knowledge (about oneself and careers); d) career decision making places a burden on memory – the feat of integrating information about the self and careers is no light task since a burden is placed on one's cognitive resources; e) the underlying decision making process is one's level of motivation, which will depend on how satisfied one wants to be with a choice; f) career development is just that: it implies growth and therefore the expansion of knowledge; g) career identity is formed by the knowledge of one's self; h) career maturity results from the ability to solve career problems adequately; i) the task of career counselling is to facilitate growth of cognitive skills (the skills aimed at solving career problems); and finally j) the counsellor aims to deliver a career problem solver and decision maker. The important issue is that career development is a learning experience and that the focus in this instance is on cognition as the main facilitator of learning (Zunker, 2006, p. 46).

3.4.2.3 Social Cognitive Theory

From the various social cognitive theories, Zunker (2006, p. 48) correctly identifies social cognitive career theory (SCCT) as the main proponent of career development theories. It is grounded in Bandura's Social Cognitive Theory and Zunker (2006, p. 44) briefly describes the elements, which were discussed in depth above, namely the triadic reciprocal causation model, the role of self-efficacy, outcome expectations and goals as the three main determinants of career decisions and development. As in the other cognitive theories, learning about oneself and about careers is considered to be important. Countering defective beliefs about one's own ability and careers is crucial to ensure correct decisions.

Zunker (2006, p. 48) identifies Hacket, Betz, Brown and Lent as the main advocates of SCCT. Their theory involves the following models explaining and guiding career development: (a) an interest-development model; (b) a choice model; and (c) a performance model. The interest model incorporates the three determinants of career- related behaviour, namely self-efficacy, outcome expectations and goals. Interest thus developed strongly for the activities and careers in which one experiences and expects competent behaviour. Exposure to activities that are mastered and that are aligned with a specific career will of course facilitate the development of an interest in that particular career (Long, Monoi, Harper, Knoblauch, & Murphy, 2007, p. 203).

The choice model stipulates the goal, the process of achieving the goal and the achievement level required to pursue a particular career.

3.4.3 Developmental theories

Although developmental theories do in some way or other acknowledge the developmental aspect of career choice, they are the theories that focus explicitly on the process of career development over a life span. They acknowledge the importance of transitions in one's life phases, and the fact they may bring about changes in self-understanding and in what one would like or have to do in one's career (Zunker, 2006, p. 52).

3.4.3.1 Life-span and life-space approach-performance approach

Like Holland, Super (1980) is well known for his particular views of career development. Super's (1980) important contribution lies in the acknowledgement of adult career development beyond the initial career choice phase in early adulthood. He acknowledges the importance of multiple life roles in the adult's life that might influence and change career trajectories (Zunker, 2006, p. 53). It appears as if he foresaw the current trend of multiple careers and career changes throughout a person's life span. The idea of self-concept also figures prominently in Super's theory. Again a match between a person's self-concept and the demands of a particular career is crucial. A person's career is an expression of his/her self-concept. Various internal and external factors form the career self-concept. Exposure to others and other careers are also important for the development of an appropriate self-concept. Super (1980) identifies a number of life stages that impact on a person's career choice and it is worthwhile mentioning them here (Adapted from Zunker, 2006, p. 54):

a. Growth (birth to age 14 or 15), characterized by development of capacity, attitudes, interests, and needs associated with self-concepts.
b. Exploratory (ages 15-24), characterized by a tentative phase in which choices are narrowed but not finalized.
c. Establishment (ages 25-44), characterized by trial and stabilization through work experiences.
d. Maintenance (ages 45-64), characterized by a continual adjustment process to improve working position and situation.
e. Decline (ages 65+), characterized by preretirement considerations, reduced work output, and eventual retirement.

The developmental stages lead to career tasks. These tasks roughly correspond to the stages. The crystallisation task (ages 14-18) happens in the phase during which the idea of a future career is formed. The specification task (ages 18-21) clarifies the career choice and is followed by preparation for the career. The implementation task (ages 21-24) happens when a job in the particular field is obtained and initiated. The stabilisation task (ages 24-35) is the phase when one's career is established, and the consolidation task (ages 35 and higher) involves an established career, movement into senior positions and settling for the long run. These tasks can of course occur at any stage as the flexibility and implementation of career paths and trajectories become more flexible.

Super developed the concept of career maturity, which seems to be a productive and useful construct (Zunker, 2006, p. 56). Career maturity involves the extent to which one can make informed and valid choices given one's competencies and interests. The dimensions that are important in career maturity are attitude towards a career, preferences, competencies and the ability to make mature decisions (Zunker, 2006, p. 56). It is interesting to note that Super's work with adolescents showed that most school-goers are not mature enough to finalise their career choices, and that the concept of career maturity can apply to persons in different stages of career development (Zunker, 2006, p. 56).

He also developed two models, namely the life rainbow and archway models (Salomone, 1996). The first depicts life's stages, roles and spaces across the lifespan. This model shows that people have different life roles, for example as students, mothers and workers, which might influence one another. The archway model shows that economic, personal and sociological aspects can influence a career (Salomone, 1996, p. 169).

3.4.3.2 Circumscription and compromise: a developmental theory of occupational aspiration

Gottfredson's (1981) model addresses the shortcomings she saw in the counselling theories of Super and Holland, amongst others. Usually career theories and guidance focus on either the content of careers or the process of career development. When they focus on developmental processes, some issues are missed although their importance is acknowledged. Gottfredson (1981, p. 545) regards intelligence, socio-economic status and gender typing as crucial for the development of a self-concept, career preferences and choice. Career theories usually focus on adolescence and the life stages that follow, but the importance that Gottfredson (1981, pp. 546-547) attaches to the determinants social status, intelligence and gender necessitates a look at the development of earlier life stages, such as when gender roles are established. She proposes looking at stages from three years and beyond, which means one's self-concept about what one would like to do as a profession is intimately linked to gender, intelligence and social status. These three variables as determinants of self-concept (along with vocational interests, competencies and values) *circumscribe* what one will be able to do (Gottfredson, 1981, p. 548). During the stages of development various barriers in occupation match and choice will be faced, and according to Gottfredson (1981, p. 549) the individual will *compromise* by letting go of certain important markers of career value: "The typical pattern of compromise will be that vocational interests are sacrificed first, job level second, and sex type last, because the latter are more central aspects of self-concept and are more obvious cues to one's social identity."

3.4.4 Person-in-environment career construction

Two theories that move the emphasis from intra-individual factors to extra-individual influences on career development are the systemic and constructivist theories (Zunker, 2006, p. 67). Systemic or ecological theories take their cue from the systems theories developed by Bronfenbenner and others, and are not actually career development theories, but rather meta-theories that explain human and social development from a holistic perspective. It is thus possible to view career choice and development within these particular meta-theories as a totality of variables that reciprocally and non-linearly influence career choice and development (Zunker, 2006, p. 67). The point this approach would like to make is that as intra-individual variables, these environmental and relationship variables play an integral part in career choice. The individual is thus imbedded in a social and community context, which is situated within a larger context, and all these contexts have reciprocal influences on an individual's choices and development (Zunker, 2006, p. 67). Systems theory, to a large extent, moves away from linear causality and a restrictive positivist view of human functioning and it is but a short step form acknowledging an individual's constitution within a social context. From here the move to constructivism is almost a given! Measurement and variables are certainly not considered in constructivism and social constructionism. One can imagine that the usual career testing, and the determination of interests, etc., as discussed above, will not apply in constructionist approaches. Since the constructivist theories are situated within a post-modernist paradigm, they emphasise the narratives and stories of people that are meaningful to themselves and others (Maree, 2010).

Zunker (2006, p. 70) conflates a number of perspectives, but moves too easily between ecological and constructivist theories, which he regards as almost similar, even though he does recognise their post-positivist roots and post-modernist situatedness. He regards Kelly's personal construct theory as being closely related to constructivism, even though the way the relationship is described in the paragraph immediately above is more accurate in respect of the logical relationship between systems thinking, social situatedness, social constructionism and constructivism. Despite the obvious similarities between ecological and constructionist theories, one should avoid placing them in the same category.

Savickas (2012) provides an example of a constructivist approach, which entails the stories that people tell about themselves and their careers. Such stories or narratives have structure and reveal the development of a person's career identity and self-concept (Zunker, 2006, p. 75). Constructivist career guidance is an effective tool for relating career phases and themes to the development of a career identity (Zunker, 2006, p. 75).

3.5 Social Cognitive Career Theory

3.5.1 Introduction

In this study the focus is on the particular area of social learning theories and specifically on Social Cognitive Theory (SCCT), which gained traction to such an extent that it was developed by a number of prominent researchers known for developing the application of career development theory fin line with the perspective of Bandura's Social Cognitive Theory (Brown & Lent, 2016). A central role is given to self-efficacy and behavioural outcomes, which in this case would be appropriate career choices, development and performance (Lent & Hackett, 1987, p. 351). The career-choice phase includes academic performance at school and career decision making at school and at the tertiary level, while the development phase includes a person's establishment of a career, transitions and maintaining a career. Performance relates to the behavioural component as the outcome of career self-efficacy and how well a person performs in a particular job. These three aspects cover the career trajectory from school to retirement (Lent & Hackett, 1987). The study undertaken by Brown and Lent (2016) is the most recent of a number of studies focused on providing an overview of SCCT.

3.5.2 Early focus on SCCT and women in non-traditional female careers

Hackett and Betz (1981) provide a programmatic framework for investigating the career development of women in the context of Social Cognitive Theory, with special reference to Bandura's views on self-efficacy (Gainor, 2006). The focus on women and their career development stems from the particular difficulties women experience when entering professional careers, and more specifically traditionally male careers. Hackett and Betz (1981) are convinced that career self-efficacy is a more powerful trait than interest, values and abilities when it comes to the limitation of women's career choices. As we have seen in Chapter 2, the current problem in STEM fields is still the lack of women entering and remaining in the field. Hackett and Betz (1981) article was written at the time when the emphasis was mainly on the lack of women in professional roles such as management, law, medicine, STEM careers and administrative positions. Despite the fact that more women were entering the labour market they were, according to Hackett and Betz (1981), restricted to low-paying and menial jobs. The past 30 to 40 years have seen women entering a variety of roles and positions, but their entry into traditionally male careers, especially STEM careers, remains an issue. When they embarked on their research, Hackett and Betz (1981) were concerned about the general lack of understanding of, and research about female vocational choices and development. Understanding how to provide women with sufficient career counselling in order to maximise their potential was a practical issue. The gender bias was much stronger in the 1980s than it is today.

How do Hackett and Betz (1981) motivate a social cognitive approach to career development, especially the career development of women? It seems as if the SCT emphasis on self-efficacy provides a core construct explaining the difficulties women experience when entering certain careers. Hackett and Betz (1981) acknowledge the processes we have addressed in paragraph 3.4.3.2 above, namely the crucial role of self-concept:

> *Societal practices require of women a robust sense of self-efficacy to pursue non-traditional vocations. In preparing for and entering careers dominated by men, they must believe strongly in themselves. Self-doubts are often difficult to override even in socially endorsed endeavours, but doubly so when non-traditional pursuits receive minimal support or are regarded with disfavour by many people. Stereotyping and discriminatory practices create additional obstacles. Progress in a career requires considerable sustained effort to produce the types of results that contribute to advancements and personal fulfilment. This is difficult to achieve if one has to fulfil the heavy demands arising from the dual workloads of career and household (Bandura, 1986, pp. 432-433).*

Bandura (1986) continues with the observation that women require a high level of self-efficacy in the social realities of work, namely the ability to establish good relations, leadership, and organisational skills.

Hackett and Betz (1981, p. 327) assume that societal beliefs and expectations are largely responsible for women's career choices and development. Other barriers do exist, but the normative role of societal expectations is fundamental and they attempt to understand how this influences the behaviour of women. They (Hackett and Betz (1981, p. 327) therefore assume that socialisation processes, mediated by cognitive processes, have an influence on women's choices and achievement behaviour. Practically this means that women grow up in a society where very clear and set expectations exists regarding what a girl/woman ought to do with her life, and it is probably not a gross overstatement to say that society (Western, but fundamentally also Eastern and African society) expects women to care for families and raise children. It is thus a given that most women will be exposed to these expectations on various levels, from childhood until they eventually try to establish themselves in meaningful careers. The point is that these societal expectations become internally accommodated by way of the socialisation process, and attempts to address this need to start with the source of said expectations. To ensure successful intervention, career counselling for women should be based on a thorough understanding of the socialisation process and how it affects women's behaviour.

Hackett and Betz (1981, p. 327) postulate that Bandura's concept of self-efficacy as the link between behaviour and socialisation provides the mechanism for understanding women's career choices and development. The strength and potential of SCT to effect behavioural change was demonstrated by Bandura's experiments with phobias (Hackett & Betz, 1981, p. 329). Certainly, if it is possible to change behaviour within a strong internalised process such as is present in the case of phobias, it should be possible to change even the effect of cultural socialisation. Sources of self-efficacy thus speak to the core components of behavioural change, and Hackett and Betz (1981, p. 330) point out the expected role of each of the four sources of self-efficacy in women's career choice and development behaviour. Since the early eighties, the relationship between self-efficacy and the various career phases and events have been investigated by many empirical studies (Betz, 2006, p. 3; Lent & Brown, 1996; Lent & Hackett, 1987).

Hackett and Betz (1981) provide an overview of career psychology by using Social Cognitive Theory and maintain that self-efficacy must be included in career issues such as:

a. Achievement behaviour
b. Academic and career decisions
c. Career adjustment
d. Applies to both men and women

They postulate that career self-efficacy plays a role in women's career development, especially when dealing with traditional male careers (Hackett & Betz, 1981). It is interesting to note that Hackett and Betz (1981) expect career self-efficacy to develop differently in women and men because of their exposure to different socialisation processes and the subsequent differential access to the four self-efficacy sources. They pose three specific questions which they felt needed to be investigated: (a) How does SE relate to career options and choice? (b) Does gender differences play a role in career-related SE? and (c) Does career counselling have an impact on CSE?

In their a lengthy overview of studies done up until the mid-1980s, Lent and Hackett (1987) provide some pointers for what future studies should focus on. Following Hackett and Betz (1981) programmatic introduction to SCCT, Betz (2007) provided a selected overview of what she regarded as some of the best examples of self-efficacy research.

Gainor (2006) provides another valuable overview of SCCT over the past 25 years from the perspective of the type of study employed to investigate self-efficacy and SCCT. SCCT is the combination or integration of career theory and Bandura's particular brand of Social Cognitive Theory. SCCT focuses explicitly on the role of self-efficacy in various dimensions of vocational aspects and includes, for example, career choice and decisions. Gainor (2006) divides the literature of the past 25 year into four groups, namely, analog studies, programme descriptions, programme evaluations and experimental/quasi-experimental studies. The categories used by Gainor refer to the research methodology used for these studies. Analog studies include those that simulate conditions for self-efficacy enhancement. Thus any one, or a combination of Bandura's efficacy sources, is used in training to see whether self-efficacy is enhanced. Programme descriptions include studies that describe programmes that incorporate interest development, career choice and performance (Gainor, 2006). Programme evaluation studies go further than descriptive studies by evaluating the effectiveness of their interventions, whereas experimental/quasi experimental studies have controlled conditions within which self-efficacy-enhancing strategies are evaluated. Gainor's (2006, p. 172) assessment of the outcome of these studies is generally positive: studies based on SCCT, which include self-efficacy-enhancing strategies based on Bandura's four sources, are generally effective and increase career decision-making self-efficacy and academic/occupational choice self-efficacy.

As will be seen in the next section, the relationship between the constellation of social cognitive variables and their influence on vocational processes and elements systematically came under investigation in a number of studies. Initially only segments of the relationships were tested in models, usually in regression or structural equation modelling studies. Gradually, with successful replication of the relationships in some studies, the models were expanded, some overlapped, new outcomes were introduced and finally a situation was reached where one can speak of integrated SCCT models. The segmental models will be discussed first, followed by a discussion of the integrated model. However, the central concepts will be listed before the two categories of models are discussed.

3.5.3 The central concepts and variables in SCCT

From the previous discussions, it should be clear that concepts and variables, such as self-efficacy and outcome expectations, are central to SCCT. However, the systematic development of various models that overlap, build upon each other and are integrated shows that a clear programme is involved to enable a holistic view of SC in vocational development (Brown, Lent, Telander, & Tramayne, 2011).

Lent and Brown (2006b) provide a brief overview of the concepts central to SCCT. These are self-efficacy, of which they identify four types (see paragraph 3.5.6.1 below), outcome expectations, goals, contextual support, contextual barriers and interests. As will be discussed in the paragraphs to follow, academic/work satisfaction and work/academic persistence are included. These are of course broader than the central concepts discussed in paragraph 3.3 above, but they are specific to the domain of career/vocational development. It must also be pointed out that although these concepts are usually studied synchronically, the extended models are currently also being investigated longitudinally, so that the SCCT approach also addresses issues of development and growth, as can be seen in, for instance, Super's acknowledgement of the developmental nature of the vocational processes (Lee et al., 2015; Navarro, Flores, Lee, & Gonzalez, 2014).

3.5.3.1 Outcome expectations

In brief, in the SCCT context, outcome expectations or the expectation of what will follow once a particular behaviour has been executed refer to work values as outcomes of participating in a particular career (Lent & Brown, 2006b). These include financial or material outcomes, status and self-actualisation issues. The positive and negative consequence of doing a particular job can be evaluated ordinally (i.e., good, neutral or bad) and it can be assumed that people will avoid negative outcomes (Lent & Brown, 2006b, p. 17).

3.5.3.2 Interests

Interests here refer to career interests and may be measured by administering the usual vocational interest tests. SCCT postulates that the higher one's belief in one's ability to do something (self-efficacy belief) is, the more likely one is to believe that certain outcomes can be reached (Flores et al., 2014, p. 82). The likelihood that one will develop an interest in those proficiency domains is therefore also high. Lent et al. (2013, p. 23) define interest in terms of how much one likes specific available subjects or activities (for example, I like biology).

3.5.3.3 Career choice and decision making

This phase normally occurs at school, usually during adolescence, but as we have seen above (paragraph 3.4.3), career decisions can be made throughout one's life. Career/subject choice is one of the crucial aspects related to self-efficacy, outcome expectations and interests. One tends to make choices (of course within enabling contexts) that support one's goals and interests.

3.5.3.4 Goals

In the context of SCCT, goals consist of choice-content goals and level-of-performance goals (Lent & Brown, 2006b, p. 17). Choice-content goals refer to the preferred content or domain one wants to focus on, for example when choosing a university major, while performance goals indicate refer to the level of attainment one wants to achieve with regard to the content goals. The three constructs self-efficacy, outcome expectations and interests in combination influence goals and persistence (Flores et al., 2014, p. 82). Goals refer to one's determination to do something or attain a level of performance, such as having subject/career goals, for instance aiming to become an engineer or studying subjects that are appropriate for one's career goals (Lent & Brown, 2006a, p. 239).

3.5.3.5 Persistence

Persistence indicates the ability or tendency to persist despite the obstacles and difficulties that are encountered in the attempt to reach one's goals and fulfil choices (Lee et al., 2015; Zeldin & Pajares, 2000, p. 218).

3.5.3.6 Contextual support and barriers

Contextual issues refer to both barriers and support structures and processes in a person's environment. Barriers may range from the typical barriers discussed in the previous chapter to a lack of support from teachers and parents. Support entails people, things and structures that facilitate one's pursuit of a career (Garcia et al., 2015).

3.5.3.7 Satisfaction

As will be seen below, academic/career satisfaction is one of the newer outcomes focused on in SCCT. In a way it stands in as a proxy for long-term career stability and maintenance. The argument is that the more satisfaction one derives from one's studies or career choices, the more likely it is that one will be able to persist in a particular direction of study or career trajectory. Satisfaction should also influence persistence and may be related to contextual barriers and support. Lent et al. (2013, p. 23) define satisfaction as overall happiness with one's field of study or work (e.g. I am absolutely delighted with what I am doing!).

Given these core concepts we now have sufficient material to examine their relationships within the various explanatory models developed in SCCT. The first steps in these investigations were focused on segments of the relationships. The social cognitive variable constellation of self-efficacy, namely outcome expectations, tends to influence a career-oriented constellation of variables such as interests, choices, satisfaction and persistence (Lent et al., 2013).

3.5.4 Segmental models

Lent and Brown (2006a, p. 237) refer to three segmental models, namely vocational-educational interest development, choice and performance. More specifically, they focus on how career and academic *interests* develop and *choices* are made, and how these influence *performance* and persistence in academic/career fields (Lent et al., 2013, p. 22). A fourth model that was added later focuses on the role of work/academic *satisfaction* (Lent & Brown, 2006a). According to Lent et al. (2013, p. 22), the first three models were supported relatively well in studies done in secondary and tertiary environments. Lent et al. (2013, p. 22) specifically point out that the Lent et al. (2005) study found support for the model focusing on choice and interest to account for differences between race and gender in an engineering training environment, which will be briefly discussed below. Lent et al. (2013, p. 23) also refer to previous research that found no difference between genders with regard to choice, interests and performance in health/biological science and computing science.

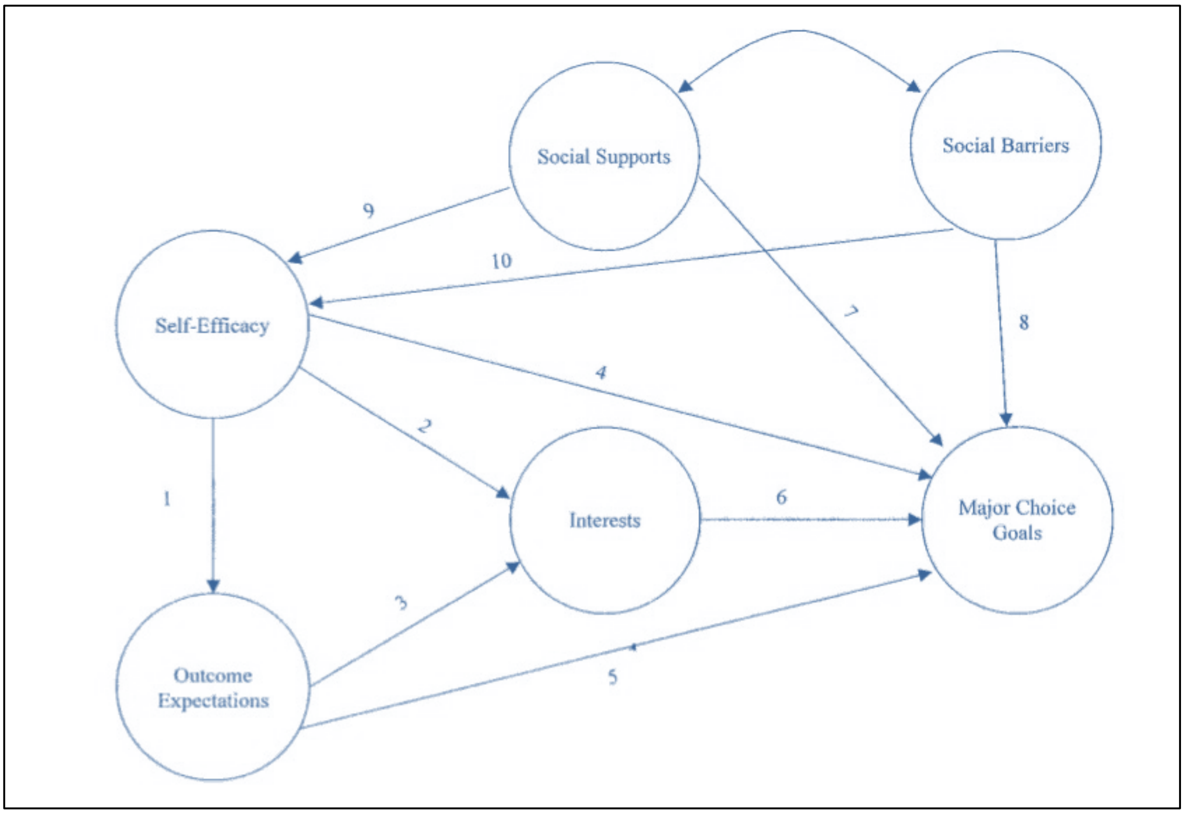

Figure 12 Path model to investigate the role of interest and goal choice. From (Lent et al., 2005, p. 86)

One example of such a segmental model is depicted in the 2005 study undertaken by Lent et al. (2005) as a path model predicting the social cognitive variables influencing choice and interests (Figure 12). In their study of male and female engineering students at three historically black and historically white universities (N = 487) they found that overall there were no significant differences across goals and interests between genders and race. Thus, as also found in other studies, engineering students showed no gender-based differences with regard to self-efficacy and outcome expectations. However, in this study Lent et al. (2005) found that females experienced fewer social barriers and more social support than their male counterparts. Figure 12 depicts the expected relationship between social barriers and support and how they influence interests and choices.

The fourth model that was developed includes academic/work satisfaction and the path model from Lent et al. (2016, p. 80), as depicted in Figure 13.

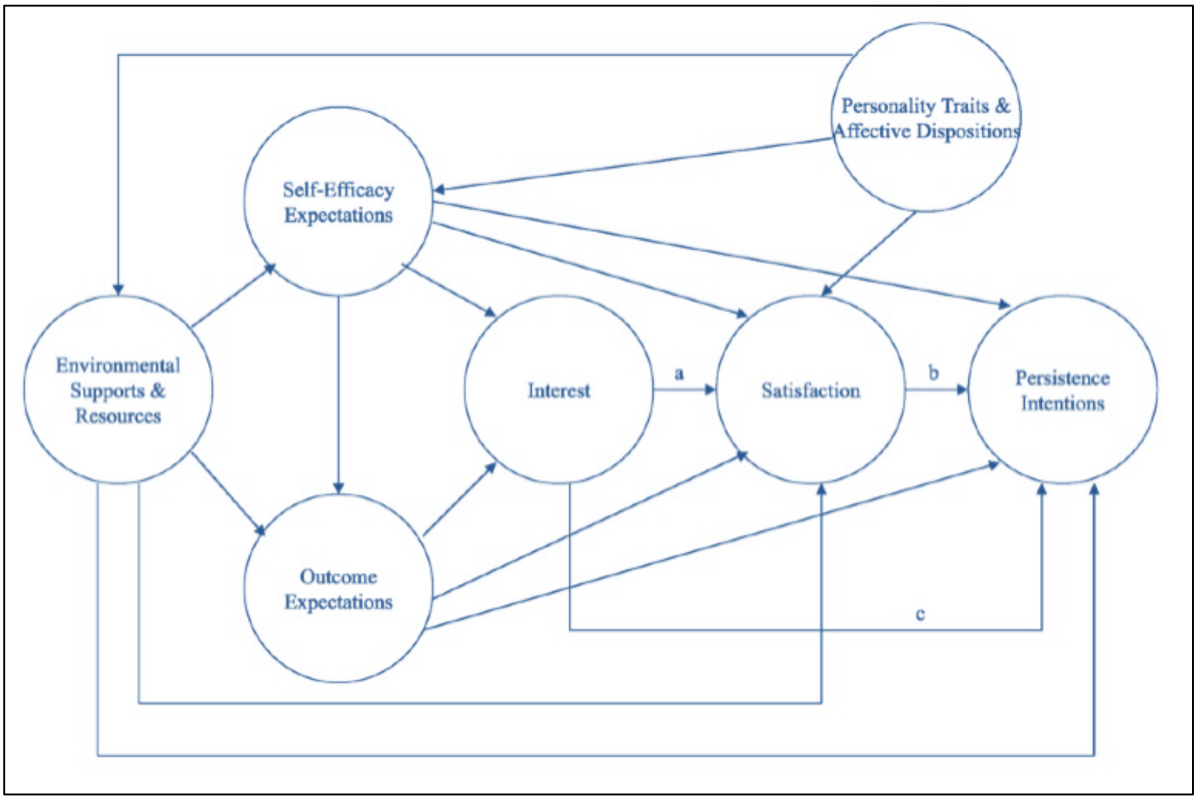

Figure 13 Integrative model (Lent et al., 2016, p. 80)

One may make the assumption that academic and work satisfaction can be viewed as indicators of academic and career persistence, i.e., continuing with one's choice of studies and remaining in a particular career. The fourth model added satisfaction and persistence intentions along with self-efficacy, outcome expectations, interests, and support and barriers. (Lent, 2004).

According to Flores et al. (2014, p. 82), research indicates significant correlations between engineering self-efficacy and engineering interests, engineering-related goals and engineering academic satisfaction (Lent et al., 2005; Lent, Sheu, Gloster, & Wilkins, 2010; Lent et al., 2008). Flores et al. (2014, p. 82) also point out that similar results were found in studies that focused on computing, mathematics and science. The relationship between outcome expectations and interest, as well as goals, in mathematics and science was supported by some studies; however, this was not the case for computing (Flores et al., 2014, p. 82). In their study, Flores et al. (2014) found no difference in the relationships between engineering academic satisfaction and the SCCT constellation of variables (outcome expectations, self-efficacy, interest, and goals all related to engineering) between genders and across certain ethnic groups, which points to the generic nature of the SCCT model. It seems as if the provision is that the variables that are measured should be specific to the area investigated; therefore it might be that the SCCT model functions similarly across groups if its content is localised.

3.5.5 The Integrated SCCT (ISCCT) model

An example of an integrated model is Lent et al. (2013) study involving engineering majors at one historically black and two predominantly white universities (N = 1377). The segmental models discussed in paragraph 3.5.4 above were combined and included satisfaction and persistence; therefore both the students' satisfaction with their academic choices and their intentions to persist in their studies were evaluated. Figure 14 depicts the findings for the full sample model. As can be seen, personality and affective indicators were also included. The major social cognitive constellations, namely self-efficacy and outcome expectations, were present and the influence of both these factors (which included interest, satisfaction and persistence) on the career constellation was evaluated. Contextual support/barriers form part of the social cognitive constellation. Lent et al. (2013, p. 27) found that

> *… interests were linked to intended persistence indirectly through satisfaction, and that the relation of support to intended persistence was mediated by self-efficacy, outcome expectations, and satisfaction. On balance, interest, satisfaction, and intended persistence were each well-predicted in the model" (see Figure 14).*

Overall the hypothesised model fits the data for the full sample fairly satisfactorily. The data was also examined across race and gender groups and the findings will be discussed below.

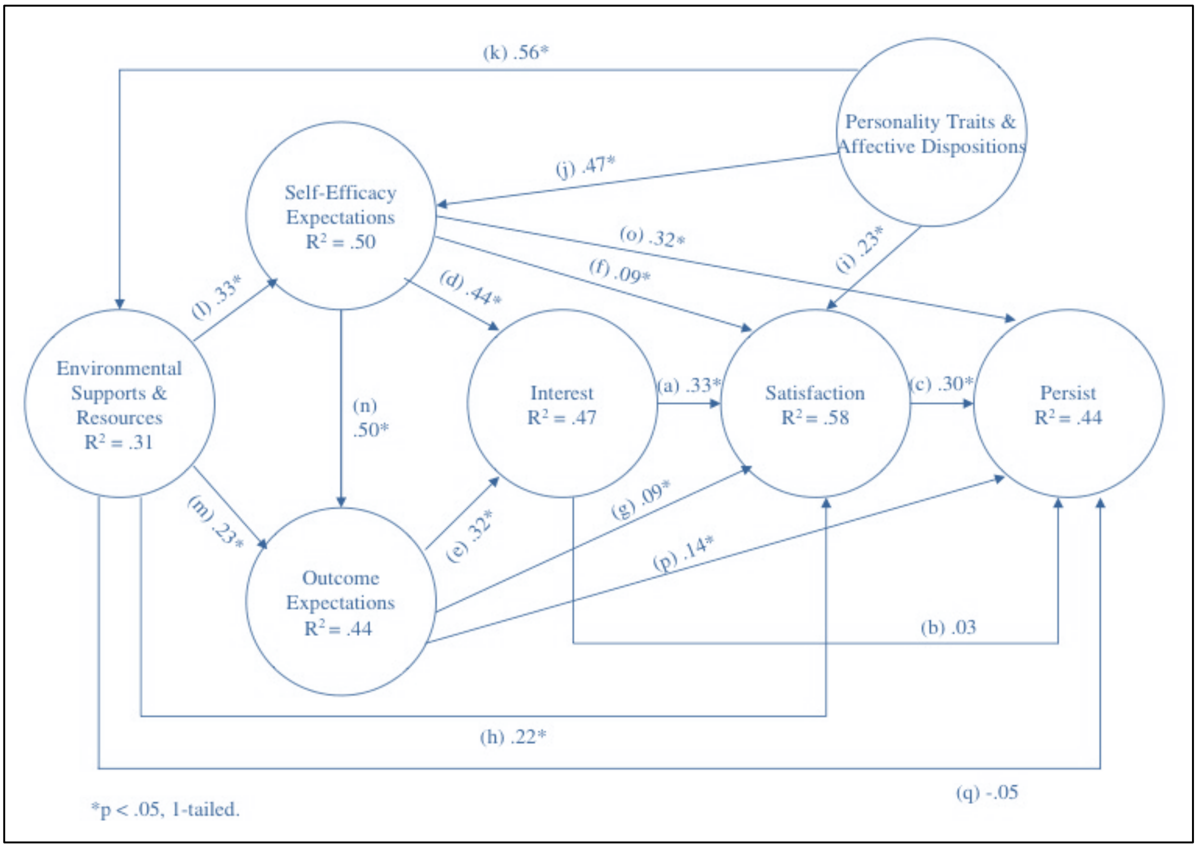

Figure 14 Integrative model for the study depicted by path diagram for the study conducted by (Lent et al., 2013, p. 23)

3.5.6 Assessment and measurement of self-efficacy

Bandura indicates three aspects or dimensions across which self-efficacy can vary, namely strength, level and intensity (Bandura, Adams, & Beyer, 1952). The measurement of self-efficacy largely followed these guidelines, but generality was not investigated in any depth. Bandar also distinguishes between general self-efficacy and domain-specific self-efficacy, arguing that general self-efficacy would not apply in the same way as specific self-efficacy across domains. Several studies that were subsequently undertaken developed and measured domain-specific self-efficacy.

3.5.6.1 Types of self-efficacy

Lent and Brown (2006b, p. 16) specified four types of self-efficacy that can be measured with a view to career issues, namely content, coping, process and self-regulatory self-efficacy.

a. Content- or task-specific self-efficacy involves a focus on ability beliefs in specific areas, such as being good at maths (Lent & Brown, 2006b, p. 16).

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b. Coping self-efficacy refers to the ability to cope with domain-specific obstacles, such as ways of achieving goals in the maths domain (Lent & Brown, 2006b, p. 16).
c. Process self-efficacy includes skills necessary for career negotiation, such as career exploration, decision making and implementation. Examples are the ability to make effective career decisions, the search for a career, negotiating work-life roles and managing role conflict (Lent & Brown, 2006b, p. 16).
d. Self-regulatory self-efficacy is a belief in one's ability to self-regulate, which implies that one might have high self-efficacy for time and workload management, which might be important for career success (Betz, 2007, p. 405). Lent and Brown (2006b, p. 16) point out that to date this type of self-efficacy has not yet received much attention.

3.5.6.2 Conceptualising social cognitive constructs

A number of instruments exist that measure aspects of social cognitive constructs such as self-efficacy. However, it is important to devise appropriate ways to measure constructs when working in a new domain. In order to ensure adequate predictive relationships, it is crucial to define a construct appropriately and make sure that it is multifaceted or wide enough (Lent & Brown, 2006b, p. 24).

Lent and Hackett (1987, p. 30) point out that a number of constructs that related facets of self-efficacy to outcomes have been measured in empirical studies in SCCT. As previously mentioned (paragraph 3.5.3 above), these are self-efficacy, outcome expectancies, interests, goals and barriers. In their 2006 study they also stated that barriers constitute the newest construct to be taken into account, and that they had not been adequately measured previously (Lent & Brown, 2006b). Again barriers and supports may be assessed too broadly to be useful for expressing self-efficacy in a particular domain. Lent et al. (2001) devised items about support and barriers in terms of the likelihood of having support or encountering particular barriers. For example: "*How likely is it that your parents will support you should you be selected for entry into an engineering programme?*" The qualification in this instance is required in order to contextualise the barrier/support. Another example might be: "*How likely is it that your spouse will support you if people make gender-discriminatory remarks in class*?"

3.5.6.3 Methodological issues

Empirical studies usually relate some predictor or independent variables to criteria or dependent variables. Lent and Brown (2006b, p. 22) indicate that the extent to which variables correspond along dimensions such as content, context, temporal proximity and level of specificity determines correlational quality. Thus, it is possible to theoretically examine construct constitution along these dimensions, and specifically the dimension of covariation.

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A predictor variable of self-efficacy should have something in common with the criterion, for example academic performance. Clearly delineating the two constructs ought to show which aspects should co-vary. However, Lent and Brown (2006b, p. 23) warn against co-variational redundancy, especially when correlations become extremely high.

3.5.6.4 Wording of items

Lent and Brown (2006b, pp. 18-19) emphasise the importance of making accurate conceptual distinctions. Self-efficacy should be expressed with "can do", an expression of ability, rather than "will do" (outcome expectation), "did do" (past achievement) or "will do" (intention or goal). It is important that the test developer should be thoroughly familiar with the construct self-efficacy and should realise that phrasing is crucial to ensure that people will understand what is meant. For example, one cannot ask people whether they think they can levitate (Lent & Brown, 2006b, p. 25)! The construct being evaluated should be under volitional control, i.e., one needs to be able to express self-agency about the behaviour, or the belief about the behaviour. Some beliefs and behaviours might be difficult, but not impossible, and might be achievable by individuals with high levels of self-efficacy. Based on good principles of test construction, the idea is of course to set sufficient hurdles across the continuum of a construct to enable accurate assessment of the level of difficulty or intensity of that construct (Lent & Brown, 2006b, p. 25): "Perceived efficacy should be measured against levels of task demands that represent gradations of challenges or impediments to successful performance" (Bandura, 2006a, p. 311).

3.5.6.5 Scaling

Lent and Brown (2006b, p. 27) provide an example in which items were scaled in such a manner as to capture Bandura's requirement of level and intensity, and Betz and Hackett (1981) asked respondents to indicate whether they possessed or lacked a particular ability. Thus, answers were dichotomous (yes/no). The same item was then rated by the respondent in terms of their levels of confidence regarding the execution of that ability (rating scale) (Bandura, 2006a, p. 312). The aggregate score of dichotomous items provides an indication of the level of self-efficacy, whilst the aggregate of the rating scale would indicate the intensity or strength of self-efficacy. Again, referring to Rasch's measurement principles, Bandura's manner of defining level and intensity is not quite correct. If a yardstick, i.e., a one-dimensional construct, is created along a single continuum, lower levels of that continuum would indicate low levels, but also lesser strength of the latent variable. Rasch allows one to match person and item measures, which simply means that the probability of endorsing an item, whether rating scale or dichotomous, provides an indication of the extent of the presence of a so-called latent variable (Stone, 2004, p. 204). Thus, strength and level is the same thing indicated by the point no further items of greater "difficulty" can be endorsed by the respondent. This is exactly what Lent and Brown (2006b, p. 27) discovered in their research: "*It was soon realized, however, that the two score types tend to be highly correlated and that strength may effectively subsume level scores and produce somewhat more reliable scales*" (Lent & Hackett, 1987).

3.5.6.6 Research on instruments and measurement of self-efficacy

Hampton (2006) investigated the Career-decision Self-efficacy Scale. The relationship between career and self-efficacy needs to be explored in terms of this specific instrument. In each instance the relationship with the scale and STEM/gender must be pointed out.

3.5.7 Career interests

Interests are regarded as a major factor influencing career choice. Hackett and Betz (1995, p. 269) point out that research shows that the development of interests converges with higher self-efficacy in those areas. In other words, it is unlikely that a person will develop a strong interest in an area where he/she does not experience high self-efficacy. One might not agree with this statement as it is entirely possible for people to develop, for instance, a high interest in a medical field without having the prerequisite self-efficacy to comply with some of the requirements for entry into this field. Another example is a person who is interested in becoming a pilot, but lacks the prerequisite psychomotor skills: no amount of self-efficacy has the ability to increase psychomotor ability.

The link between self-efficacy, skills, interest and career-specific requirements needs to be carefully examined. However, to return to the initial point, Hackett and Betz (1995, p. 269) do temper their statement with the observation that career interests and SE are "moderately" related, and that the joint prediction of career success might be probable. In a another publication a year later, a "substantial" relationship is claimed for SE and outcome expectancies with career interests (Lent, Hackett, & Brown, 1996, p. 20). This is followed by a claim for a relationship between interests and self-efficacy, which places the reservation expressed in the paragraph immediately above in context. The developmental path does not lead from interest to self-efficacy, which my examples imply, but the reverse: interest tends to develop in those areas in which a person has high self-efficacy (Lent et al., 1996, p. 20).

This is confirmed by Lent et al.'s (1996, pp. 7. 20) theoretical framework: the development of career interests must be seen against the backdrop of the influence of self-efficacy and outcome expectations. Children can be exposed to and participate in career-related activities at school, in the community and at home. Participation allows skills to be developed, and mastery of those skills, or even verbal feedback about the activities, may lead to a belief in

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what to expect as outcomes. In this way mastery or self-efficacy and successful outcome expectations lead to an increase in interest, while a dislike may develop for areas in which a person is not successful: "*… people are seen as performing enduring interest in an activity when they expect the activity to produce valued outcomes"* (Lent et al., 1996, p. 7). One might not be convinced that this holds across cases; therefore this problem should be empirically examined. For instance, Social Cognitive Theory is adamant that career interests have to develop through self-efficacy and outcome expectations, despite the emphasis placed by other theories on the development of skills and abilities in the process of mediating interests. It is possible that someone might retain an interest in an activity in which he or she does not excel. Participation in artistic activities is a good example: one may like singing even if one is not a good singer. According to Social Cognitive Theory, a person who does not have a good singing voice will end up disliking it or having a low interest in it.

3.5.8 Self-efficacy and career choice and development

Self-efficacy theory, along with Bandura's understanding of self-efficacy, is subsumed under Social Cognitive Theory (Williams, 2010, p. 418). Career development and related issues form a focal point within Social Cognitive Theory to such an extent that one can speak of "social cognitive career theory" or SCCT (Lent et al., 1996, p. 4). The aim of SCCT is to incorporate the following issues, given that career development and choice issues are usually spread over a number of fields and theories: (a) the development of academic and career interests; (b) understanding the different levels of performance in careers and the fact that people remain in some careers longer than in others; and (c) grasping the relationship between interests and other variables, and how these influence career choices. Bandura's Social Cognitive Theory, as described above, forms the framework for integrating these issues (Lent et al., 1996, p. 5). Bandura (1986) developed a "triadic reciprocal model of causality" consisting of personal attributes, external environmental factors and overt behaviour, which systematically influence each other. This model (see Figure 9 below) is dynamic and, unlike other models of career development that incorporate trait theories of personalities, it departs from the "state" perspective of personal characteristics (Lent et al., 1996, p. 5).

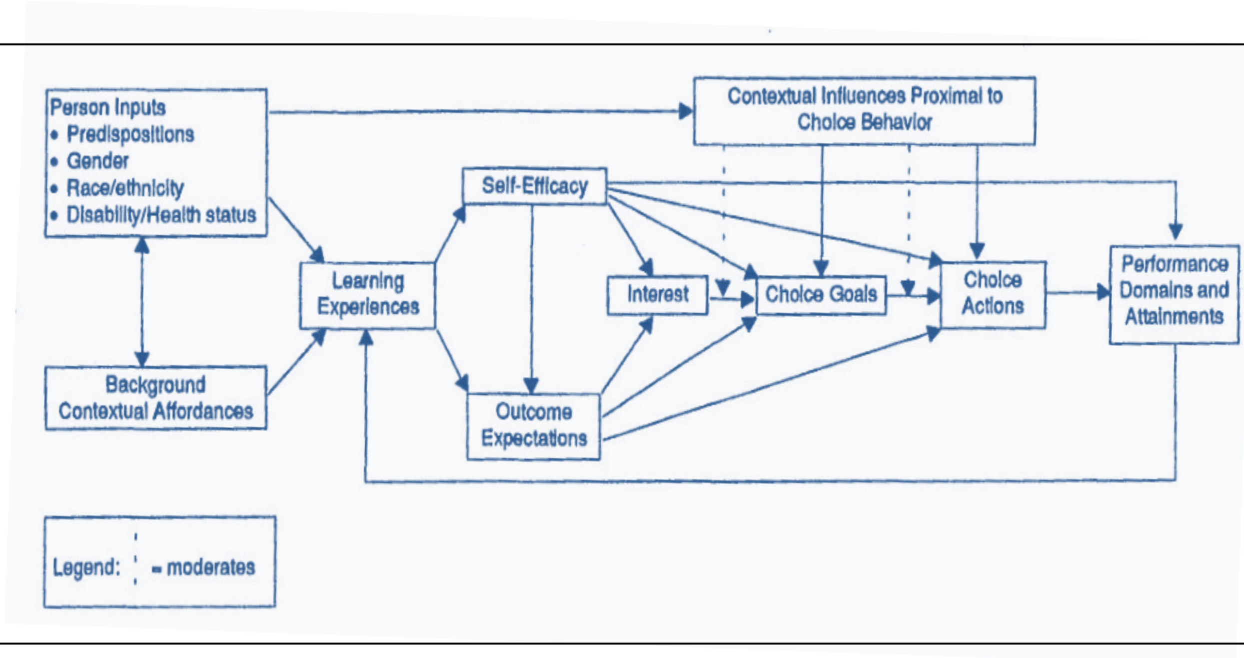

Figure 15 Factors influencing career decisions (Lent et al., 1996, p. 10)

The personal attributes, as conceptualised in SCCT, consist of self-efficacy beliefs, outcome expectations and personal goals (Lent et al., 1996, p. 6). Self-efficacy and its sources were briefly discussed above. Outcome expectations refer to a belief that a certain outcome will be achieved when certain actions have been executed. Personal goals can be described as the intention to "engage in a certain activity or to effect a particular outcome" (Lent et al., 1996, p. 7). Planning or goal setting is crucial for career planning, but the relationship and interaction between these three constructs are even more important. Thus one's belief in what one can do determines one's career choices. However, self-efficacy and outcome expectation are closely related since to some extent the outcome of an intended set of behaviours aimed at achieving specific goals depends on the belief of what one can achieve. Some debate has developed regarding the relationship between outcome expectancy and self-efficacy: Bandura defines self-efficacy as causally influencing outcome expectancy, but it seems as if the converse is also possible (Williams, 2010).

3.5.8.1 Initial findings relating to women and careers

In their 1981 empirical study, Betz and Hackett (1981) found that men and women do not differ in respect of the levels of CSE for traditionally male or female careers when focusing on their gender-specific careers. They also do not differ in respect of typically gender-non-specific careers (such as medical physician or lawyer). However, they do differ for gender-related non-traditional careers. These authors (Betz and Hackett (1997) further found that men and women do not differ in respect of their levels of self-efficacy when entering corresponding gender careers. In fact, males had high self-efficacy for both traditional and non-traditional careers, while women showed markedly lower self-efficacy for non-traditional female careers. Gender role socialisation and practices usually militate against women entering so-called male vocations. Women therefore scored lower on self-efficacy for careers such as engineering and men scored lower for careers such as nursing. To evaluate the relationship between self-efficacy and career, Taylor and Betz (1983) developed a Career Decision-Making Self-Efficacy Scale (CDMSES) to measure self-efficacy expectations. Nevill and Schlecker (1988) research confirmed that female undergraduate students with high CDMSES scores were willing to be involved in career-related activities of non-traditional occupations (Luzzo, 1993, p. 195). Other instruments were also developed, such as the Career Search Efficacy Scale and the Skills Confidence Inventory (Gainor, 2006). Several studies confirmed the role of self-efficacy in the case of subjects such as maths and science. The research done by Hackett and Betz (1989) and Brown, Lent, and Larkin (1989) clearly showed that self-efficacy, and not ability and past experience, was the predicting factor in career choice. Studies involving ethnical diverse engineering students also showed that higher self-efficacy is a predominant factor in career choice (Hackett, Betz, Casas, & Rocha-Singh, 1992).

The call for research to be extended beyond college students was heeded by Post-Kammer and Smith (1985, 1986) (Betz & Hackett, 1981). In their first study, which involved a sample of high school learners and a smaller number of careers than used by Betz and Hackett (1981), they found similar results. A review of the results by Lent and Hackett (1987) indicated that the differences might be accounted for by the high school students' lack of self-efficacy crystallisation. However, the more likely reason is the small sample subjected to regression analysis (Lent & Hackett, 1987).

The second study showed that both self-efficacy and career interest predicted the the difference between men and women's interest in math-related careers (Post-Kammer & Smith, 1986). In the case of men, only career interest played a role and overall the influence of gender was insignificant. Lent and Hackett (1987, p. 353) pointed out that gender was not controlled for in Post-Kammer and Smith's (1986) study, and that cultural issues could have influenced the outcome as the sample was rather mixed.

A third study examined the role of self-efficacy and the locus of control in career choice (Layton 1984). Self-efficacy was found to be a better predictor of career choice than LOC for women choosing between traditionally male/female occupations. The women showed higher self-efficacy for traditionally female occupations. Layton introduced another interesting variable, called career salience, which acted as a moderator between self-efficacy and career subject

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choice. Layton also investigated career exploitation behaviour and found that self-efficacy did not predict career exploitation behaviour.

Lent and Hackett (1987) subsequently discussed the work of Wheeler (1983), who formulated an alternative and interesting conceptualisation of self-efficacy. Self-efficacy was operationalised as the number of women in traditional careers and then arranged on a continuum from low to high. Women's perceptions were then assessed in terms of the match of their abilities to their careers, thus self-efficacy was defined as "career ability match" (Lent & Hackett, 1987, p. 354). Self-efficiency correlated well with career preference, but Wheeler found that career valence should be included in a predictive model. The definition of career valence is unclear and Lent and Hackett cast doubt on Wheeler's (1984) definition of self-efficacy, which differed from that of Bandura.

Lent and Hackett (1987) discussion of various studies involving self-efficacy, gender and career choice and success, provides a helpful schema for the evaluation of similar research. The two important variables that should be present are self-efficacy and the issue of the content of career or occupation in whatever way the latter is defined. The quality of the instruments, the construct validity of the variables, the nature of the sample, the analysis method and the eventual conclusion are important.

While the abovementioned discussion looks at the content of career choices, i.e., which majors or career paths students have actually chosen, other aspects of career choice need to be considered. As Lent and Hackett (1987) point out, issues such as career decision-making processes also need to be examined.

If women's self-efficacy for non-traditional careers is low, this could explain why so few women enter SET careers. The relationship between self-efficacy and success in a SET career was examined in two qualitative studies using Bandura's (1986) four self-efficacy sources as framework. In the first of these, Zeldin and Pajares (2000) found that women in SET careers depend much more on vicarious and support experiences than on performance experiences for high levels of self-efficacy. This was surprising, given the predictions of Social Cognitive Theory that mastery experiences have more weight in forming positive self-efficacy beliefs. Women thus depend much more on positive role models and verbal support from others in significant relationships. Both the role model and social support sources seem to involve significant others, such as parents, peers, teachers and supervisors. This slightly extends Bandura's theory as it seems that if the role model or supporter is not in some significant relationship with the woman, the effects on self-efficacy will not be as marked. Zeldin and

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Pajares (2000) stress the context of relationships within which women find support and where their self-efficacy is sustained.

In the second study, Zeldin et al. (2008) compare the females who participated in Zeldin and Pajares (2000) study to a group of males in SET careers. It was found that males depend much more than females on performance experiences and less on vicarious and support experiences. Mastery of activities was important in forming men's self-efficacy beliefs, and other sources of information largely corroborated their already established beliefs about their capabilities. From such research, it appears as if men and women differ with regard to how they utilise sources of information for selecting careers and continuing in those careers. Supportive social environments are much more important to women and their determination to succeed is strengthened when they see that other significant women have achieved their goals.

Zeldin and Pajares (2000) found that the high levels of self-efficacy noted in the women in their sample made them more resilient to the negative effects of the obstacles encountered in their careers. According to Bandura (1986), women with established self-efficacy regarded obstacles not as failures, but as challenges to overcome. Self-efficacy thus allowed them to develop resilience and perseverance in the face of obstacles. Two types of resilience were identified by Zeldin and Pajares (2000), namely academic and social resilience. The first refers to the women's perseverance in completing their studies, while the second refers to their ability to overcome social discrimination. High self-efficacy also relates to high levels of job satisfaction and positive work-related attitudes (Wang, Lawler, & Shi, 2010, p. 300).

One could refer to engineering students' experiences in their study environment. According to Jungert and Rosander (2010, p. 647), a student's study environment can be described as "*highly demanding, extremely pressurised with heavy workloads.*" These circumstances contribute to students' feelings of not being in control and being overburdened. Jungert and Rosander (2010, p. 647) further maintain that academic self-efficacy enhances students' ability to cope. Academic self-efficacy is the student's ability to accurately judge his/her own capacities and to adapt to studies and pass successfully (Bandura, 1986). Bandura also states that students with high levels of self-efficacy will more frequently attempt more challenging tasks and will persist longer to complete them. They also tend to focus on opportunities and influence their study environment by adapting various strategies. Jungert and Rosander (2010, p. 655) found clear evidence of a significant association between students' self-efficacy and their academic achievement. This study involved master's programme students in Electrical Engineering and Computer Engineering. Although female students represented only

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9% and 12% of the respective groups, no differences were found in the female and male students' levels of self-efficacy (Jungert & Rosander, 2010, p. 652).

3.5.8.2 Women and sources of self-efficacy

The four sources of self-efficacy allowed Hackett and Betz (1981, p. 330) to postulate possible differences between men and women in terms of career development. Table 4 provides a summary of those differences. Performance mastery for men ought to function differently because of the inherent predispositional male/female characteristics. Men tend to be aggressive, domineering, motivated, extroverted, etc., while women tend to be emotionally driven, softer, focused on relationships, submissive, etc., which are all characteristics that are not considered to be amenable to overt practising skills.

Subsequent empirical research proved these gross generalisations to be largely false. We now know that any so-called masculine or feminine traits are to a large extent attributable to a socialisation process. The point is though that current societal demands afford boys more opportunities to practise certain masculine skills from an early age whilst girls are discouraged from practising and displaying the same skills. Furthermore, the link between self-efficacy and self-mastery suggests that men tend to internalise mastery experience while women tend to ascribe success to external events and circumstances (Hackett & Betz, 1981, p. 330). The tendency to externalise and not claim responsibility for one's success might be at the root of the so-called importer syndrome that women frequently experience. Both the appropriateness of the social and developmental context affording opportunities for practising and mastering skills and the internalising of self-efficacy/mastery provide testable assumptions.

The availability of role models for both men and women in non-traditional female careers is an obvious source of self-efficacy expectations (Hackett & Betz, 1981, p. 331). More male than female role models are available in SET careers. However, even though 20 years down the line more women role models are available, the STEM fields still lack sufficient numbers of women. The causal link between role models and self-efficacy in this instance is not really clear.

Third, the physiological states of arousal and experiences of anxiety are assumed to be higher in women than in men (Hackett & Betz, 1981, p. 332), which leads to the further assumption that women's tendency to experience more anxiety would have a negative effect on their internalisation of self-efficacy.

Lastly, verbal persuasion simply boils down to boys getting the encouragement to pursue and excel in non-traditional-female careers while girls do not. The lack of verbal support and encouragement for girls is as much the fault of social acculturation processes as that of, for instance, career counsellors, teachers, parents and the media (Hackett & Betz, 1981, p. 333).

Table 4 A model depicting the postulated effects of traditional female socialization on career-related self-efficacy expectations (Hackett & Betz, 1981, p. 333)

Self-efficacy sources	Examples of women's socialisation experiences	Effects on career-related self-efficacy
Performance Accomplishments	Greater involvement in domestic and nurturing activities, but less involvement in sports, mechanical activities and other traditionally "masculine" domains	Higher self-efficacy with regard to domestic activities, lower self-efficacy in most other behavioural domains
Vicarious learning	Lack of exposure to female role models representing the full range of career options. Female role models largely represent traditional roles and occupations	Higher self-efficacy with regard to traditionally female roles and occupations, lower self-efficacy in non-traditional female roles
Emotional arousal	Higher levels of anxiety are reported by feminine gender-typed individuals	Further decreases in both generalised and specific self-efficacy
Verbal persuasion	Lack of encouragement and/or active discouragement from pursuing traditionally male activities/careers, e.g. maths and science	Lower self-efficacy expectations with regard to a variety of career options

3.5.8.3 Gender differences in segmental and integrated models

As discussed above, Lent et al. (2013) examined the integrated model (Figure 14), with the inclusion of satisfaction and persistence along with the usual social cognitive constellation (N = 1377). The study was conducted at one historically Black university and two predominantly White universities and involved students in their final year of engineering studies. The ethnic groups were divided as follows: White (n= 802) and ethnic minorities (African, Hispanic and Asian Americans and others; n= 568) (Lent et al., 2013, p. 28). Gender was divided into men (n = 918) and women (n = 456) (Lent et al., 2013, p. 27). The structural model was evaluated separately across gender and race. In both instances no significant differences were found in the model to account for the relationship between the social cognitive constellation variables and satisfaction and persistence (Lent et al., 2013). Interesting though was the finding that significant variance was explained by satisfaction and persistence for both men and women, but more so for women (Lent et al., 2013, p. 27).

It is important to note that the integrated SCCT model evaluated by Lent et al. (2013) focused on the relationship between the social cognitive variables, their influence on choice and interest, and subsequently the latter's influence on satisfaction and persistence. Their model showed that interest is crucial to students being satisfied with their choices and their intention to remain within the field. This finding seems obvious, but as we have seen above, Holland's RIASEC model assumes a fit between interest and job performance. The SCCT model provides a somewhat broader explanation of why fit between interest and academic/work choice is important. Underlying the relationship is the motivational impetus provided by self-efficacy and outcome expectations. Their conclusion, which is quoted below, is important for this study:

> *… the present findings extend social cognitive inquiry on person and environment factors* ***that may promote or deter adjustment to engineering majors****. We specifically found support for an integrative model that weaves together elements of SCCT's interest, choice, satisfaction, and performance models. The model fit the data well both in the full sample and in sub-samples of women and men and in students of racial/ethnic majority and minority groups. These findings suggest that the SCCT framework offers potential for explaining the processes through which* ***students become attracted to, and subsequently decide to remain in (or leave), STEM fields***" (Lent et al., 2013, p. 29) (researcher's own emphasis).

A clearer picture of why students choose to remain in or leave STEM/SET study fields and careers is slowly emerging. From the initial assumptions that self-efficacy and related social cognitive variables have a direct influence on people's decisions to remain in their careers (in this instance SET careers) or to leave them, a number of aspects need to be taken into account, among others the extent to which social cognitive variables bolster interest, satisfaction and persistence. A related matter is that of gender differences. Like men, women also require high levels of self-efficacy, outcome expectations, social support and strong interest, and have to experience satisfaction and intention to persist and succeed.

In a subsequent study Lent et al. (2016, p. 80) studied the integrated SCCT model that included academic/work satisfaction and academic/work persistence intention over time in a group of engineering students (N = 908; Women: n = 332, Men: n = 576; White: n = 64 %) at two tertiary institutions and compared the stability of the models across race and gender. The study included university entry academic performance (SAT) scores and final degree academic performance.

The major findings were that predicted actual persistence, i.e., the successful completion of the degree, related to self-efficacy, satisfaction and persistence intention (Lent et al., 2016, p. 86). These relationships also held true for gender and ethnic groups. Overall the findings of previous studies were confirmed: the social cognitive constellation variables largely predicted satisfaction and persistence intentions[12] (Lent et al., 2016, p. 85). It should be noted that it was found that over time interest informed satisfaction, and vice versa, which suggests that they are in a reciprocal relationship (Lent et al., 2016, p. 86).

SAT scores, self-efficacy and final academic performance were moderately related. It seems as if individuals with higher pre-university entry ability have moderately better self-efficacy and eventually perform better (a relationship that held across groups). Lent et al. (2016, p. 88) concluded: "*Thus, students are likely to benefit when they both enter college with sufficient levels of objectively measured ability and when they view their capabilities confidently once enrolled in college.*" Academic performance is generally important for students, but for those who experience satisfaction and are determined to persist despite obstacles such as poor academic performance, it is probably more important to remain on course and achieve their goals than to excel (Lent et al., 2016, p. 81). A large body of research focused on performance versus growth goals and motivation consistently found that students with internal motivational structures do not perceive performance excellence in comparison to other students as being important (Brown & Lent, 2016, pp. 545,558). The point is that it is probably much more important to find out whether students persist in their academic choices (as is the case with job incumbents persisting in their careers of choice) and to determine the nature of the relationship to the social cognitive variable constellation. In this case Lent et al. (2016, p. 87) focused indirectly on entry ability (SAT scores) and academic performance and found that higher entry ability and enhanced self-efficacy increased performance and persistence. The important contribution of their study was its implementation as a longitudinal study, since most researchers do cross-sectional evaluations. (Lent et al., 2016, p. 85) thus found that gender and cultural diversity does not influence persistence intentions over time, which again supported the generic applicability of a localised model.

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[12] "Controlling for auto-regression, positive affect was predictive of support and self-efficacy; support and self-efficacy were predictive of outcome expectations; self-efficacy and outcome expectations were predictive of interests; support, self-efficacy, and interests were predictive of satisfaction; and self-efficacy and outcome expectations were predictive of persistence intentions" (Lent et al., 2016, p. 85).

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3.6 Conclusion

Social Cognitive Theory focuses on the role of agency and specifically on self-efficacy and outcome expectation in people's ability to direct and change their behaviour. It views human beings as being embedded within a social context, but also as people who are able to regulate their future to a large extent. Behaviour is influenced by any number of internal and external factors and people do not merely react to an environment, but act and cause things to happen. The extent to which people believe they can change their own behaviour and environment depends largely on the levels of their self-efficacy beliefs. Empirical research has shown that a number of achievements in various contexts depend on self-efficacy beliefs. In career development studies, the role of self-efficacy and SCT were incorporated from an early stage in the development of SCT. The main argument was that women seem not to enter or remain in STEM fields, and SCT might be able to illuminate the reason for this phenomenon. If careers that are not traditionally chose by women require a special set of female skills and perceptions, self-efficacy might be the crucial element allowing women to enter and remain in STEM fields. Their success or failure will then depend on the levels of their self-efficacy beliefs and their ability to cope and overcome obstacles and barriers.

Some research indeed showed that self-efficacy played a role and that there is a difference in how sources of self-efficacy operate in men and in women. Later developments of social cognitive career theory or SCCT became more sophisticated and examined more complex relationships between self-efficacy and outcomes, as well as the moderating and mediating role of various variables. What was first seen as segmental models, i.e., models restricted to examining the self-efficacy-outcome relationship with one or more variables at a time, developed into an integrated endeavour. These models are called integrated SCCTs and note the influence of issues such as choice, interest, decision making, satisfaction and longitudinal performance. SCCT is thus becoming a theory incorporating development and major activities at different times during career development.

It is becoming apparent that in relation to other aspects, self-efficacy plays a role in whether people, especially women, choose careers in the STEM field in particular, and remain in them. There is no linear or one-to-one relationship between self-efficacy and outcomes.

CHAPTER 4
RESEARCH METHODOLOGY

4.1 Introduction

This chapter explores the different aspects of the mixed-method research approach, which was the methodology applied in this study. The research question and the research design will be discussed, after which the sampling of the participants, the measurement instruments used, data collection procedures and data analysis will be explained. Finally, the ethical considerations of the study will be discussed and the chapter will conclude with a brief summary.

4.2 Research question

The research question for this study was formulated as follows:

> *What is the role of self-efficacy in the different career trajectories of (a) women who remain in the STEM field for at least three years, and (b) women who trained for STEM careers but chose not to follow those careers, or decided to leave the field for some or other reason?*

The research question was formulated to explore the role of self-efficacy in women who had studied in the fields of Science, Technology, Engineering and Mathematics (STEM) and who subsequently either followed careers in their field of study, or made career changes. The literature study in Chapter 3 confirmed that self-efficacy plays a significant role in enabling women to enter and pursue careers in the STEM field (Zeldin, Britner, & Pajares, 2008; Zeldin & Pajares, 2000). However, many women studies in the STEM field and never enter the field, or may enter the field but after a time opt for a career change. The question this study seeks to answer is whether those leaving STEM fields do so because of a lack of self-efficacy. Investigation proceeded from a social-cognitive perspective using a mixed-methods approach in order to determine whether self-efficacy is necessary and/or sufficient for STEM career success, and how it relates to the structural and individual factors that either prevent or enable women's success in those careers. Although structural and individual barriers are often used as an explanation for the shortage of women in STEM careers, self-efficacy may explain why some women remain in STEM careers despite the barriers that they experience.

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4.3 Research aim and objectives

4.3.1 The aim of the research study

The main aim of this study is to explore the role of self-efficacy in the career trajectories of women who studied in the STEM fields.

4.3.2 The objectives of the research study:

The researcher aimed to achieve the purpose of the study by meeting the following objectives:

a. To examine the role of self-efficacy in women who have remained in STEM careers for at least three years
b. To investigate the role of self-efficacy in women who studied in the STEM fields, but left their fields or made a major career change within the first three years after they had completed their studies
c. To determine whether, with regard to self-efficacy, women who have established careers in STEM differ significantly from those who made career changes.

4.4 Research design

This study implemented a mixed-methods design using quantitative and qualitative methods. (Creswell & Clark, 2011, p. 5) described mixed-methods as a

> *… research design with philosophical assumptions as well as methods of inquiry. As a methodology, it involves philosophical assumptions that guide the direction of the collection and analysis and the mixture of qualitative and quantitative approaches in many phases of the research process. As a method, it focuses on collecting, analysing, and mixing both quantitative and qualitative data in a single study or series of studies. Its central premise is that the use of quantitative and qualitative approaches, in combination, provides a better understanding of research problems than either approach alone.*

This definition clearly makes provision for the combination of more than one method of data collection in one research design. Teddlie and Tashakkori (2009, p. 7) describe this as a type of research design in which both qualitative and quantitative approaches are used throughout the research process. This includes the way questions are formulated, data is collected and analyses are done. The motivation for a mixed-methods approach will be discussed below.

4.4.1 Motivation for a mixed-methods approach

The research phenomenon or question under consideration does not necessarily require a specific approach. The research question, which relates to why some women remain in stem careers while others leave, necessitated neither a qualitative nor quantitative approach. However, the manner in which the research unfolded and the realisation that one should actually talk to women to find out why they made specific choices in their career trajectories indicated a need for interviews, and the way in which the researcher wanted to utilise the data or information obtained by way of the interviews indicated that a qualitative approach would be appropriate. Furthermore, since the study aimed at determining levels of self-efficacy and wanted to investigate how women perceived barriers and a host of related issues that were very specific, a need for of measurement instruments and questionnaires was indicated. The approach to, and analysis of the latter required a quantitative approach. A mixed-methods design seemed to be the obvious choice, but in this instance, it had to be one that allowed for the simultaneous collection of data. A parallel convergent design seemed the best option (Creswell & Clark, 2011, p. 77).

One of the major requirements when using a combination of different designs and methods is to ensure that the eventual interpretation and understanding of the phenomenon under question makes conceptual sense and does so coherently (Teddlie & Tashakkori, 2009, p. 286). An overall theoretical framework or conceptual framework that manages to integrate and facilitate an understanding and explanation of the phenomenon is crucial to the mixed-method approach. One may not put fragmented and incoherent data into one framework. Issues such as the nature of the data and the proper method to use to inform the qualitative-quantitative design debate and these paradigms can be viewed in various ways (Yardley & Bishop). The choice of a pragmatic approach for this study merely means that the phenomenon had to be understood from different angles due to the nature of the information available. It is close to what Onwuegbuzie, Johnson, and Collins (2009, p. 134) call a pragmatic-of-the-middle approach (rather than a left or right , or overtly pluralist vs staunchly realist approach). Middle pragmatism is outcome-oriented and practical. The pluralism involved in this instance entails the acknowledgement of the validity of the investigation of phenomena by applying multiple methods and techniques (Frost & Shaw, 2015, p. 387).

4.4.2 The parallel convergent design

Figure 16 below depicts the steps suggested by Creswell (2012, p. 555) for designing a mixed-methods study. These steps cover everything from determining whether a mixed-methods study would be appropriate for a one- or two-phase study, to writing the report. In this instance, a two-phase study was decided on in order to facilitate triangulation. This approach can best be captured by the parallel convergent design.

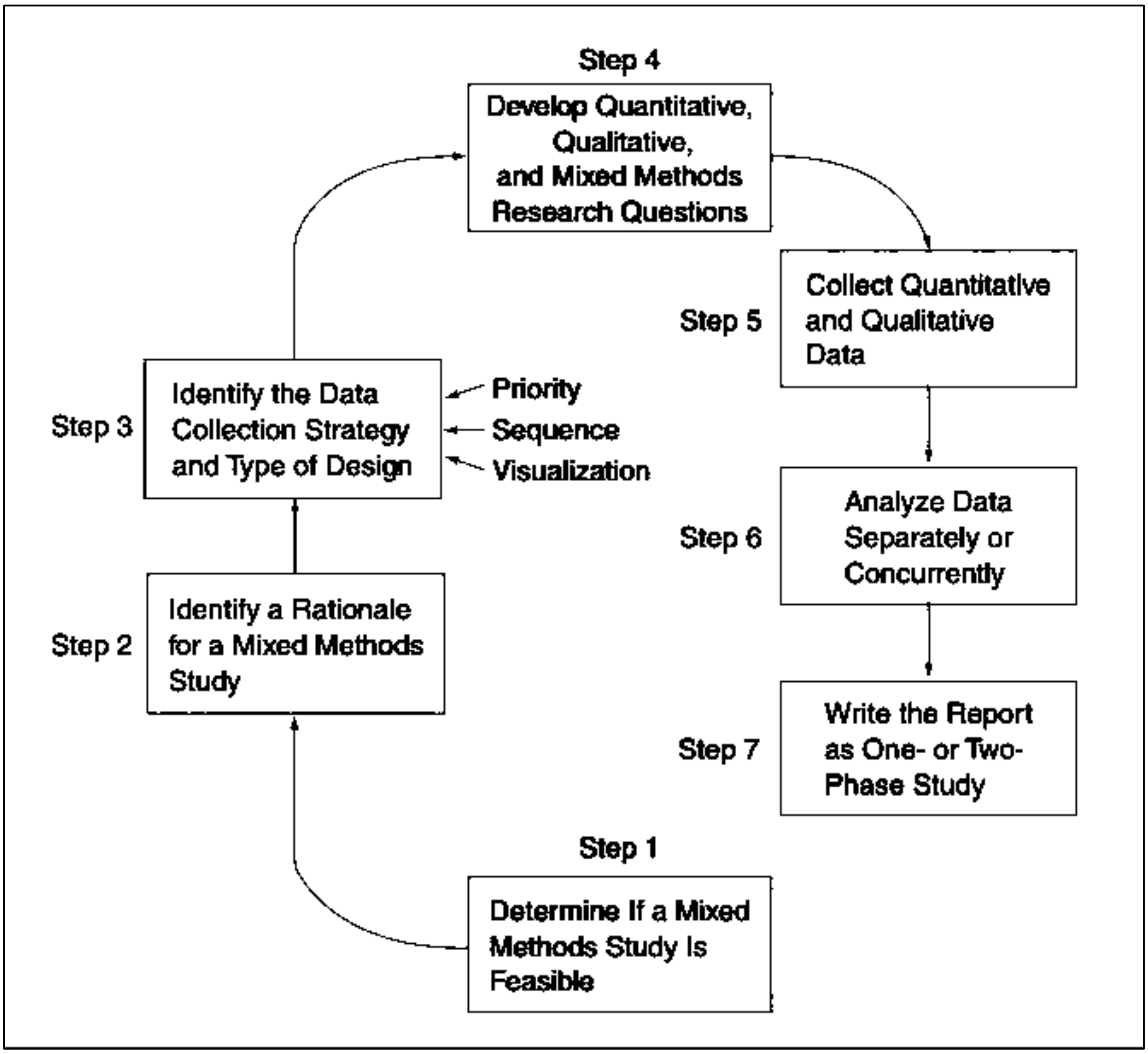

Figure 16 Steps in designing a mixed-methods study (Creswell, 2012, p. 555)

Creswell and Clark (2011) provide an illustration of the parallel design (see Figure 17). The qualitative and quantitative strands are separated, but are fairly concurrent. Traditional qualitative and quantitative methods are used to collect the data and analyse the data. Samples generally differ in size, with the qualitative design using a small sample and the quantitative design a larger one to make it possible to address quantitative validity issues (Shadish et al., 2001).

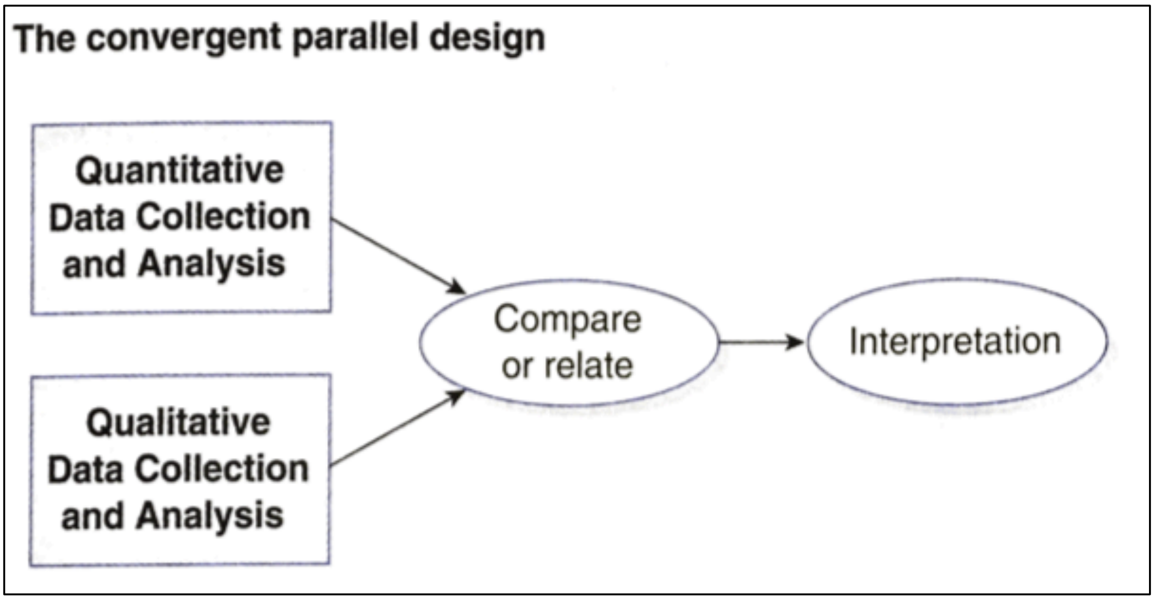

Figure 17 The convergent parallel design (Creswell & Clark, 2011, p. 69)

The purpose of a parallel convergent design is to compare data about the topic under consideration that might differ (Creswell & Clark, 2011, p. 77). This design can combine the strengths of qualitative and quantitative techniques, such as combining the information obtained from a small qualitative sample with that obtained from a large quantitative sample in order to increase the validity of the conclusions drawn about a phenomenon. However, it can also be used to obtain multiple perspectives to increase understanding of a phenomenon. Finally, should there be a convergence of divergence between the conclusions, data patterns or interpretation, understanding of the phenomenon and the context within which it is operating or was studied can be clarified.

4.4.3 Principles of triangulation and complementarity

The motivation for using both quantitative and qualitative approaches in this study was twofold: the principles of triangulation and complementarity facilitate the understanding of the phenomenon under question (Creswell & Clark, 2011, p. 62). Triangulation seeks to merge the different methods for the purpose of validating inferences. The first principle of triangulation will be applied in the study as it views information from two different perspectives. According to Creswell and Clark (2011, p. 62), triangulation brings together the opposing strengths and non-overlapping weaknesses of quantitative methods with those of qualitative methods. In this instance the role of self-efficacy in career success in two groups of women will be examined by conducting interviews and assessing their levels of self-efficacy and related positive psychology constructs by using quantitative instruments.

Complementarity seeks the explanation, improvement and interpretation of the results obtained by using one method with the results obtained by way of the other method. These two principles will guide the design on the levels of collection, analysis and interpretation of data. As recommended by (Creswell & Clark, 2011, p. 65), the study will place equal emphasis on the analysis and interpretation of data. The second principle of complementarity will be applied in this study by using quantitative and qualitative data collection methods in order to supplement inferences made from either one or the other (Creswell & Clark, 2011, p. 5). For instance, when women say that they experience feelings of self-efficacy or hopelessness, this information can be complemented by quantitative comparisons of levels of self-efficacy.

4.4.4 Steps in the parallel convergent design

Creswell and Clark (2011) describe the design of a parallel convergent design in four steps. It is also depicted in Figure 18 below. Four basic steps are involved, namely design and data collection, analysis, the merging of results and the interpretation of the results. The data collection and design of the qualitative and quantitative parts are done independently. The two processes therefore do not influence each other, as happens in other qualitative designs. In other words, the one data collection process does not depend on the other (Creswell & Clark, 2011, p. 78). Even the analyses of the two sets of data are done separately and independently. Each thus follows its own method for analysis. The third step involves combining the information provided by the two results, and in the fourth and final step the results are interpreted in terms of the extent to which they converge or diverge.

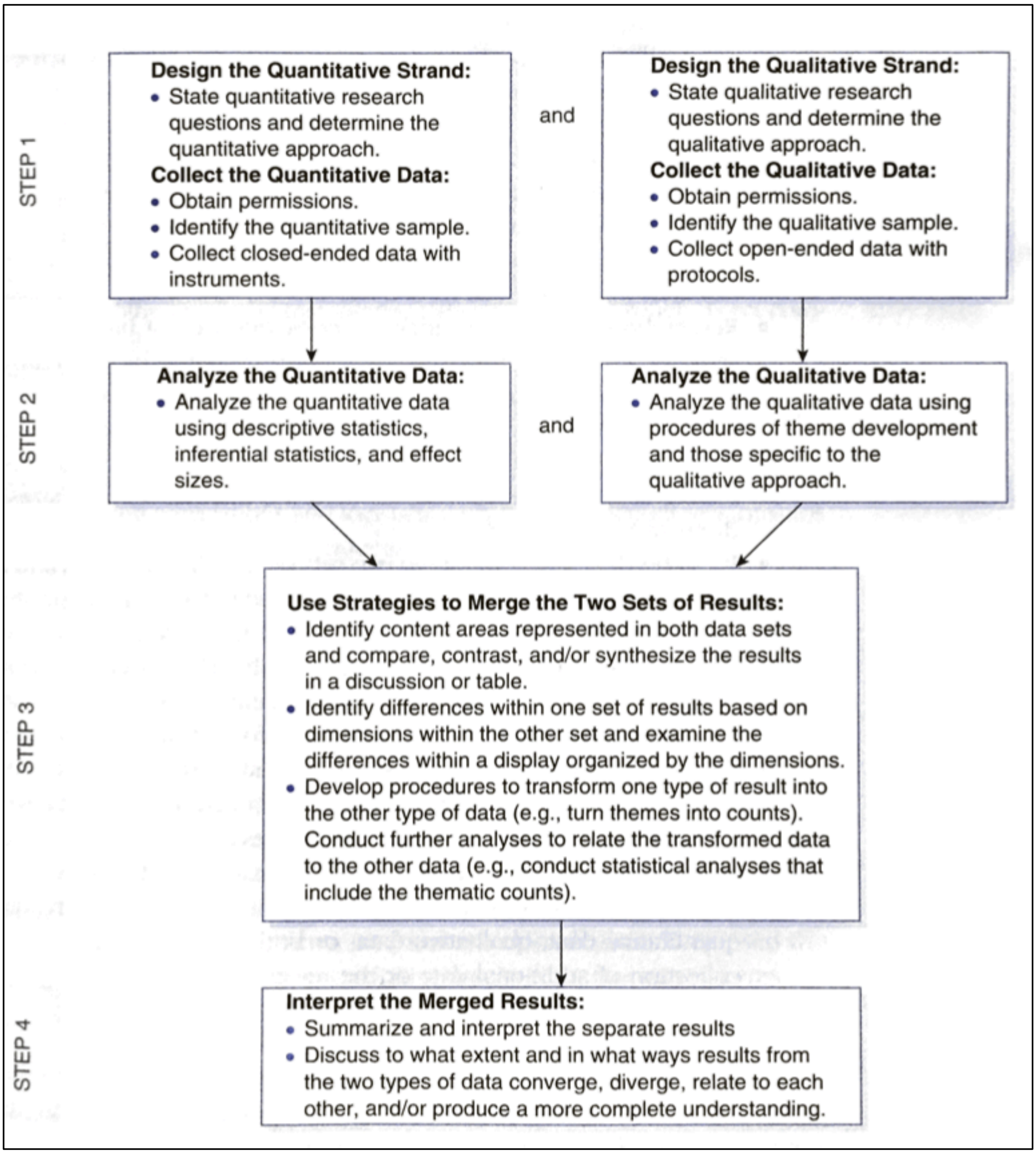

Figure 18 Steps in the convergent design (Creswell & Clark, 2011, p. 79)

Creswell and Clark (2011) also point out the strengths and weaknesses of the convergent design. The strengths include the legitimacy of using different methods together. In this sense the combination of methods in a convergent design is highly pragmatic and not so much motivated by either a positivist or qualitative paradigm. Another advantage is the efficiency of implementing both methods concurrently as the processes are not mutually dependent. However, the major disadvantage beyond the standard problem of combining incompatible paradigms is the incomparability of samples and methods, and the difficulty of integrating data sets (Teddlie & Tashakkori, 2009, pp. 83-102). These problems can, however, be overcome by ensuring validity or at least reporting on validity issues in each process. One concern that can arise before a study is actually embarked upon, is what to do if the results do not converge (Creswell & Clark, 2011, p. 80).

4.5 Sampling

The sampling approaches followed for both the qualitative and the quantitative studies are discussed in this section.

4.5.1 Qualitative sample

A purposive sample of two groups of women was identified. Teddlie and Yu (2007, pp. 80-83) discuss different types of purposive sampling, amongst others sampling for representativeness, sequential sampling, using multiple purposive techniques and sampling for "special or unique cases." In this instance, women were sampled explicitly as "special or unique cases" (Teddlie & Yu, 2007, p. 80). The first group included women who have worked in STEM careers for at least three years, while the women in the second group had studied in STEM fields, but, for various reasons, had decided not to pursue related careers, or had left them after relatively short periods. Purposive sampling was chosen as the method of sampling owing to the difficulty of tracing women in STEM careers, and the even more difficult process of trying to trace women who were appropriately qualified for STEM careers, but had decided to leave them (Guest, Bunce, & Johnson, 2006, p. 61; Struwig & Stead, 2001, p. 122). For the purpose of this study, this method was better than random sampling as it was essential to obtain a group that could provide rich information and experiences (Miles, Huberman, & Saldaña, 2014; Struwig & Stead, 2001, p. 122). It was assumed that women both in and out the field knew others in similar situations, which could provide a point of reference.

4.5.1.1 Sampling method and process

In order to identify the two groups of women, the researcher contacted several STEM-related organisations and universities that offer STEM-related degrees. The first organisation that was contacted was the South Africa Agency for Science and Technology Advancement (SAASTA), which is a business unit of the National Research Foundation (NRF) with a mandate to advance public awareness and appreciation of, and engagement with science, engineering, innovation and technology in South Africa. SAASTA has access to prominent women scientists in South Africa. The researcher also approached other organisations, such as the CSIR, iThemba and the Department of Science and Technology. In an attempt to identify women who had studied science but had made career changes, the researcher approached scientists in the field and asked them for referrals to colleagues who had left the field. In the quantitative questionnaire, the researcher also requested references to women who had studied in STEM fields, but had never pursued STEM-related careers. Despite this strategy, it was particularly difficult to find women who had studied in the STEM fields but had subsequently decided to follow other career paths.

The inclusion/exclusion criteria were the following:

a. STEM group: Women who remained in their STEM careers for at least three to five years. The researcher will refer to this group as the STEM group.
b. Non-STEM group: A second group of women who had studied in the STEM fields but never worked in a STEM field, or decided to leave it in order to follow other careers. The researcher will refer to this group as the non-STEM group.
c. Age: Women in the age group 30–50 years , with the exception of one respondent who was much older but was included because of her contribution to science and her personal story.
d. Employment experience: STEM-group respondents had to have at least three years' experience in their chosen careers, or had to have spent this length of time after their studies in one of the selected career fields. The non-STEM-group respondents included women who had studied science, but either never entered the field, or worked in the field for any length of time before opting for a career change.
e. During the selection of participants, preference was given to women working or studying in the fields of aerospace, chemical, civil and electric and electronic engineering, physics, nuclear physics, natural science and mathematics. This specification was based on three sources indicating women's representation in STEM, namely, *Labor force characteristics by race and ethnicity, 200*9 (U.S. Department of Labor, 2009), Census 2011 (Statistics South Africa (Stats SA), 2011) and *List of occupations in high demand: 2014* (Department of Higher Education and Training, 2014). According to these three sources, women were especially underrepresented in the following scarce-skill careers:
    - Aerospace engineering
    - Chemical engineering
    - Civil engineering
    - Electric and electronic engineering
    - Research in the fields of mathematics, analysis and methodology
    - Mechanical and metallurgical engineering
    - Physics
    - Nuclear physics

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- Science (natural sciences)
- Environmental engineering

f. Geographical area: Respondents had to be from South African cities or towns in at least three provinces. The sample did represent three provinces, namely the Free State, Gauteng and the Western Cape.

The researcher also requested several institutions to recommend women scientists who are renowned in their fields of work (often in the fields stipulated above). The organisations that were approached in this regard were the South African Agency for Science and Technology Advancement (SAASTA), the Council for Science and Industrial Research (CSIR) and iThemba Laboratories. The researcher also approached, among others, the University of Pretoria and the Department of Science and Technology for referrals to prominent female scientists.

It was no easy task to trace women who had studied science and subsequently made career changes, thus leaving STEM. The researcher approached the scientists who participated in the study for possible referrals to women who had studied in the STEM-field but never entered the field, or left the STEM-field for various reasons. A question was also added to the qualitative questionnaire asking for referrals to women who had studied STEM but did not enter the field at all or decided to leave it. Only two names were provided through this option. The data was collected between May 2015 and June 2016.

Guest et al. (2006, p. 61) provide a summary of the different opinions and guidelines for qualitative interview sample sizes. Guidelines recommend sample sizes of 10 to 60 or more, depending on the type of analysis done. Most guidelines recommend that interviews should continue until theoretical saturation is reached (Guest et al., 2006, p. 61). This is a difficult requirement to comply with, especially since sample size has to be practically planned for from the proposal phase. It was decided to aim for a sample of 10, with five participants in each STEM-status group. However, failure to reach saturations while the interviews were being conducted necessitated additional interviews. Ultimately the sample included 15 participants of whom eight represented the STEM group and seven the non-STEM group. See Appendix A for the interview guide. The respondents in the sample requested that they remain anonymous.

4.5.1.2 Sample characteristics

In this section, the focus is on the sample attributes. The sample profiles of the respondents are indicated in Table 5 and Table 6.

Table 5 Sample profile of women in STEM

	Profession category	Name	Age	Race	Qualification	Employment sector	Years in STEM at time of interview
1	Electric and electronic engineer	Participant A	46	W	MEng	Education sector	12 years
2	Laser scientist (Physicist)	Participant B	31	W	PhD (Science)	Research institute	3 years (1 year in senior research position)
3	Geographer: specialisation in cultural and socio-political geo and geo of gender	Participant C	78	W	PhD (Science)	Education sector	37 years
4	Ionospheric physicist Space scientist	Participant D	32	B	PhD (Science)	Research institute	4 years
5	Nuclear physicist	Participant E	44	B	MA (Science)	Research institute	11 years
6	Civil (structural) engineering	Participant F	30	W	MEng	Education sector	7 years (2 years in current position)
7	Mechanical engineer	Participant G	32	B	BSc Mech Eng	Engineering company	2 years in current position
8	Applied mathematician and physicist	Participant H	46	W	BSc	External contractor	12 years (5 years in current position)

Table 6 Sample profile of women in the non-STEM group

	Category (initial field of study)	Name	Age	Race	Qualification	Employment sector (whilst in STEM career)	Years in STEM before leaving
1	Geologist	Participant I	43	I	BSc	Education sector	Did not work in the STEM field
2	Quantitative geneticist	Participant J	48	W	MSc	Education sector	15 years
3	Chemical engineer	Participant K	--	B	BEng	Industrial/ technology sector	6 years
4	Mathematician	Participant L	41	W	BScHons	Education sector	Did not work in the STEM field / 16 years in current field of work
5	Agriculture specialist	Participant M	47	W	MSc	Research institution	3 years (15 years in current field of work – not STEM related)
6	Civil engineer	Participant N	46	W	BEng	Entrepreneur	2 years
7	Electronic engineer	Participant O	44	W	BScEng	Research institution	6 years

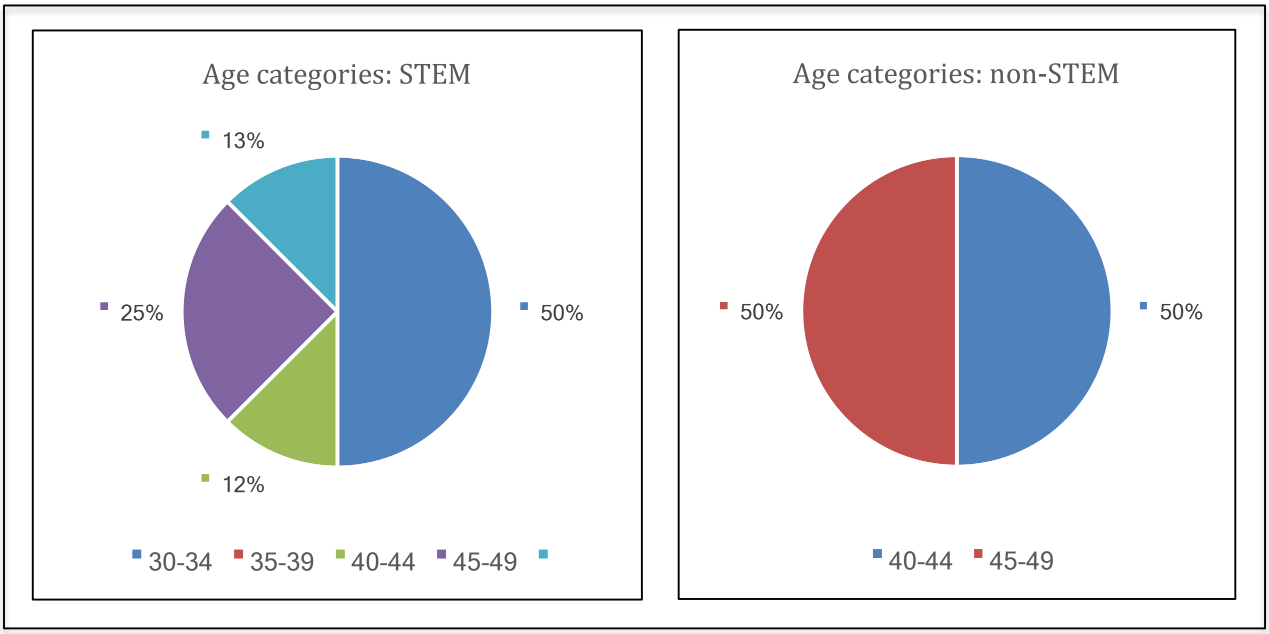

Figure 19 Age categories for STEM-status groups

A summary of the age categories of the STEM and non-STEM groups is presented in Figure 19, and a presentation of race distribution can be seen in Figure 20

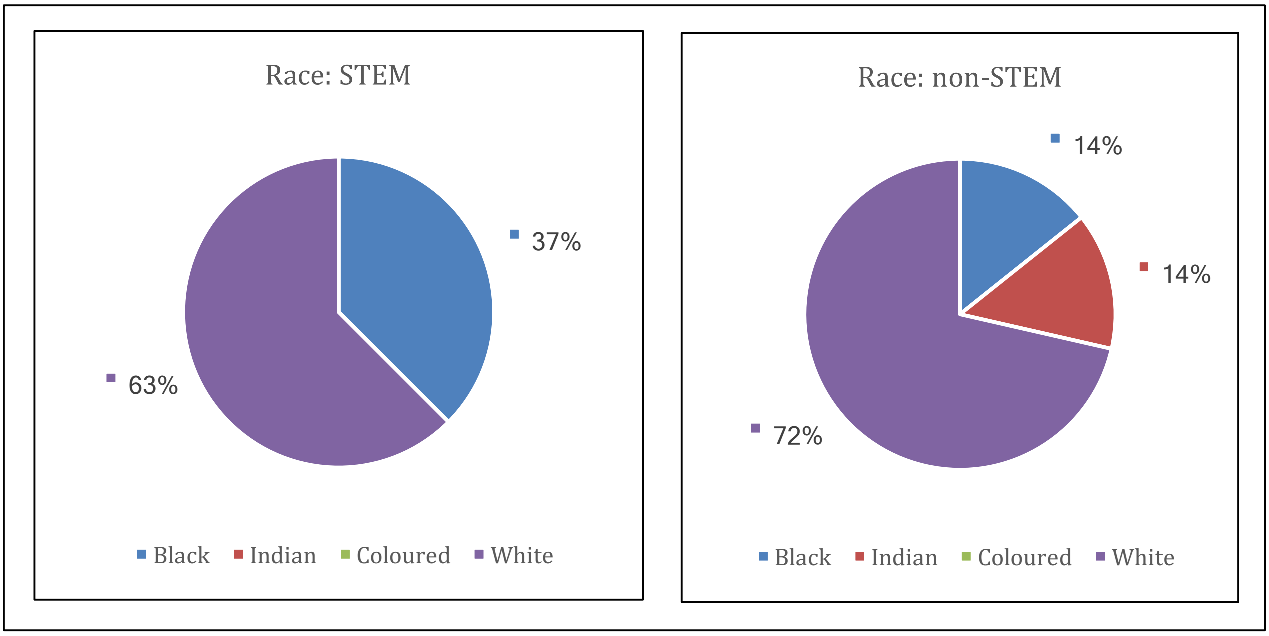

Figure 20 Race for STEM-status groups

The mean age of the STEM group was 42.4 years (SD = 16.02). Their ages ranged from 30 to 78 years. The mean age of the non-STEM group, who were between the ages of 41 and 48 years, was 44.8 years (SD = 2.64).

The participants' fields of specialisation were:

a. Engineering: chemical, civil, electric and electronic, and mechanical engineering
b. Science: agriculture specialist, geographer (geo of gender), geologist, ionospheric physicist, nuclear physicist, mathematician, quantitative geneticist
c. Mathematics: applied mathematician, operations research and statistics

Three of the participants in the STEM group had doctoral degrees and one of them was a professor. Three had master's degrees and two had completed BSc degrees. In the non-STEM group two participants had master's degrees, one had an honours degree and the rest had basic STEM degrees.

4.5.1.3 Summary

The sample characteristics can be summarised as follows: Three of the participants in the STEM group had doctoral degrees and one was a professor. Three had master's, and two had BSc degrees. Two of the participants in the non-STEM group had master's degrees, one had an honours degree and the rest had basic STEM degrees.

The quantitative sample will be discussed in the next section.

4.5.2 Quantitative sample

The sampling of the quantitative section of the study differed from the process described above. A random sampling approach was not feasible owing to the lack of systematic and thorough information on women in the different STEM fields, or on women who had left the STEM fields. Participation depended to a large extent on volunteers who had indicated that they were prepared to become involved in this research. The strategy was mainly purposive as specific organisations were approached and requested to distribute the survey. The strategy also included a snowball element as participants were requested to refer other women who were in STEM careers, or had been in them and had left and who might agree to participate (Whitley, 2002). To some extent this was also convenience or volunteer sampling as it relied on the willingness of the participants (Teddlie & Yu, 2007, p. 78).

4.5.2.1 Sampling method and process

Questionnaires were sent to several organisations, including the Agricultural Research Council (ARC), Aurecon, the Academy of Science of South Africa (ASSAf), the Department of Science and Technology, the National Research Foundation (NRF), the National Science and Technology Forum (NSTF), the CSIR, ESKOM, iThemba Labs and the South African Agency for Science and Technology Advancement (SAASTA). Universities with strong science and/or engineering programmes, such as the University of Pretoria (UP), the Cape Peninsula University of Technology, the University of Cape Town, the University of Johannesburg, UNISA and the University of the Witwatersrand (WITS) were also approached. Emails were sent to individuals whose email addresses were available or whose titles, names or photos indicated that they were women.

Science organisations specifically for women were also approached to request to them send the questionnaire to their members. However, some of the organisations declined the request. The organisations that were approached were Women in Engineering (Womeng), the International Women's Forum (IWFSA) and the Association of South African Women in Science and Engineering (SA WISE). The online science magazine of the National Science and Technology Forum (NSTF) was also requested to place a request for women to complete the questionnaire.

It was very difficult to identify and access women who had studied in the STEM fields but worked in other fields. The online questionnaire also included an item requesting the respondents to refer the researcher to women who had left this field, and the women who were interviewed were asked to provide the names of other women who were no longer working in the field.

The response rate was low (N = 145) and the researcher requested a number of organisations (that employ women in science careers) to redistribute the request for participation in the study. These organisations included ASSAf, iThemba Labs and Women in Nuclear Science (WINNSA). A total of 162 completed questionnaires were received, but only 108 were usable. The STEM group was represented by 88 participants and the non-STEM group by only 20. The data was collected between May 2015 and September 2016.

4.5.2.2 Sample characteristics

In this section, the realised sample characteristics are presented.

Table 7 Language of total sample (N = 108)

	Frequency	Percentage	Valid percentage	Cumulative percentage
English	72	66.7	66.7	66.7
IsiXhosa	4	3.7	3.7	70.4
IsiZulu	1	.9	.9	71.3
Sepedi	2	1.9	1.9	73.1
Sesotho	3	2.8	2.8	75.9

	Frequency	Percentage	Valid percentage	Cumulative percentage
Afrikaans	20	18.5	18.5	94.4
Setswana	3	2.8	2.8	97.2
Other (specify)	3	2.8	2.8	100.0
Total	108	100.0	100.0	

According to Table 7 the majority of women participating in the electronic survey were English (66.7%), The second largest group were Afrikaans (19%) whilst the remainder consisted of Black women (15%).

Table 8 Marital status of total sample (N = 108)

	Frequency	Percentage	Valid percentage	Cumulative percentage
Married	69	63.9	63.9	63.9
Single	29	26.9	26.9	90.7
Divorced	3	2.8	2.8	93.5
Widow	2	1.9	1.9	95.4
Married (traditional)	5	4.6	4.6	100.0
Total	108	100.0	100.0	

The majority of women in the sample (N = 108) was married (64%) while 27% were single (Table 8). By adding the traditionally married women to the married category 74 (69%) were married while 34 (31%) were single by grouping widow and divorced with the single category. The cross tabulation between STEM status and relationship status would be informative. This is examined below.

Table 9 Highest qualification of total sample (N = 108)

	Frequency	Percentage	Valid percentage	Cumulative percentage
Grade 12	1	.9	.9	.9
Technikon Diploma	4	3.7	3.7	4.6
Bachelor's degree	12	11.1	11.1	15.7
Honours degree	36	33.3	33.3	49.1
Master's degree	54	50.0	50.0	99.1
Doctoral or PhD degree	1	.9	.9	100.0
Total	108	100.0	100.0	

Interestingly one person has Grade 12 – one would expect this person to be one that did not study further thus left the STEM field (Table 9). A large proportion (33%) has honours degrees while 50% or the majority has master's degrees. Almost 15% of the women have a tertiary degree or diploma.

Table 10 Currently in STEM career (N = 108)

	Frequency	Percent	Valid percentage	Cumulative percentage
Yes	88	81.5	81.5	81.5
No	20	18.5	18.5	100.0
Total	108	100.0	100.0	

The sample is unevenly divided between those that are currently in STEM careers and those that are not (Table 10). Of the sample of 108, 82 % or 88 are currently in a STEM career while 20 or 18 % left or did not enter the STEM field. This variable is crucial for further analyses and will be used to divide the sample into two independent groups in order to explore the differences on sample characteristics, biographical information and test results.

Table 11 Current company of total sample (N = 108)

	Frequency	Percentage	Valid percentage	Cumulative percentage
Non-governmental Organisation	2	1.9	2.0	2.0
Engineering Consultants/Company	3	2.8	3.0	5.0
Education	74	68.5	73.3	78.2
Own Business	4	3.7	4.0	82.2
Research Institute	11	10.2	10.9	93.1
Government Department	6	5.6	5.9	99.0
Unemployed	1	.9	1.0	100.0
Total	101	93.5	100.0	

From Table 11 it is clear that 69% of the sample work in the educational sector. Eleven women worked in research institutes and about 6% in government departments. Seven women (6.5%) did not indicate their current company.

Table 12 Current position of total sample (N = 108)

	Frequency	Percent	Valid percentage	Cumulative percentage
Management	19	17.6	18.1	18.1
Consultant	3	2.8	2.9	21.0
Trainer	1	.9	1.0	21.9
Scientist	9	8.3	8.6	30.5
Student	14	13.0	13.3	43.8
Academic	57	52.8	54.3	98.1
HR	2	1.9	1.9	100.0
Total	105	97.2	100.0	

The majority of women have educational positions (53%) while three did not indicate their current position (Table 12). The second largest group occupies management positions.

Table 13 Age categories of total sample (N = 108)

	Frequency	Percent	Valid percentage	Cumulative percentage
20-24	3	2.8	2.8	2.8
25-29	12	11.1	11.1	13.9
30-34	29	26.9	26.9	40.7
35-39	20	18.5	18.5	59.3
40-44	8	7.4	7.4	66.7
45-49	13	12.0	12.0	78.7
50-54	10	9.3	9.3	88.0
55-59	5	4.6	4.6	92.6
60-64	7	6.5	6.5	99.1
65-69	1	.9	.9	100.0
Total	108	100.0	100.0	

Almost 60% of the sample were younger than 40 with the majority in the 30 to 39 category. Thirty-three percent of the women were 45 to 69 years. Except for the 30 to 39 year slot the other categories were relatively evenly spread.

Table 14 Years in current position of total sample (N = 108)

	Frequency	Percent	Valid percentage	Cumulative percentage
0-3	58	53.7	55.8	55.8
4-6	21	19.4	20.2	76.0
7-9	11	10.2	10.6	86.5
10-12	7	6.5	6.7	93.3
13-15	2	1.9	1.9	95.2
16-18	1	.9	1.0	96.2
22-24	1	.9	1.0	97.1
25-27	1	.9	1.0	98.1
28-30	1	.9	1.0	99.0
40-42	1	.9	1.0	100.0
Total	104	96.3	100.0	

From Table 14 it is apparent that most participants were a relatively short time in their current positions. This can mean one of three things, namely, they get promoted often, they change jobs often or the younger people fall in this category (or a combination of the three issues). Almost 54% were in their current jobs for 0 to 3 years while 19% 4 to 6 years. The remainder were in their current positions 7 years or longer.

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4.5.2.3 Summary

Additional sample characteristics are discussed in Chapter 6. The majority (66.7%) of the women who participated in the electronic survey were white and English speaking. The second largest group (19%) were white and Afrikaans speaking (19%), and the remaining 15% were Black. Most (64%) of the women in the sample (N = 108) were married and 27% were single. A large proportion (33%) had honours degrees and the majority (50%) had master's degrees. Almost 15% of the women had a tertiary degree or diploma. Sixty-nine percent of the sample worked in the education sector. Eleven women worked in research institutes and approximately 6% in government departments. Seven participants (6.5%) did not identify their current employers in order to protect their own identities. Almost 60% of the women in the sample were younger than 40, and the majority of those were in the category 30 to 39 years. Thirty-three percent of the women were between 45 and 69 years old. With the exception of the 30 to 39 years group, the age categories were relatively evenly spread.

4.6 Data collection

In this section, the data collection process is to be discussed. According to Creswell and Clark (2011, p. 6), mixed-methods research involves the collecting and analysing of both qualitative and quantitative data to obtain answers to the research questions (Creswell & Clark, 2011, p. 179). Different types of mixed-methods use different data collection methods with diverse

sampling strategies that include asking a range of questions during data collection. The different approaches support the researcher's understanding of the research problem, which is greatly facilitated by having more than one data set, rather than only one. Quantitative data are usually of a closed-ended nature, while qualitative data consist of open-ended information supplied by participants in their own words (Creswell & Clark, 2011, p. 13).

Since data collection and analysis for both the qualitative and quantitative strands took place simultaneously, the researcher used a convergent parallel design. The interpretations of the two data sets will be compared to the other set and integrated in a final interpretation, as suggested by Creswell and Clark (2011, pp. 69, 71-88).

In the following section the data collection process will be discussed, starting with the collection of the qualitative data.

4.6.1 Qualitative data collection

Qualitative data collection was done by way of interviews based on a semi-structured interview schedule (Willig, 2008, p. 23). A purposive sample consisting of two groups of women was identified. The first group included women who have worked in STEM fields for at least three years, while those in the second group had studied in the STEM field, but had decided to leave their careers for various reasons. Both groups were asked to complete the questionnaire about self-efficacy.

The purpose *"… of the interview in qualitative inquiry is to create a conversation that invites the telling of narrative accounts (i.e., stories) that will inform the research question*" (Josselson, 2013, p. 4). In this instance the career stories were guided by a semi-structured guide and, where necessary, participants were invited to elaborate on points that were not clear to the researcher.

Interviews were arranged by scheduling appointments for face-to-face interviews with the participants who had agreed to be interviewed. The interviews were planned according to the semi-structured interview schedule (Table 15). The researcher started each interview by first requesting the interviewee to complete a consent form to confirm her willingness to participate in the research, to give permission for the interview to be recorded, and to agree to the use of the recorded information. It also guaranteed the anonymity of the interviewee and stated that, should she wish to do so for any reason, she would be free to terminate her participation at any time. See Appendix C for the consent form. Following the completion of the consent form, the interviewee was asked to complete the biographical details form (see Appendix D).

All the interviews were recorded (with the permission of the participants) and the material was subsequently transcribed. See Table 15 below for the semi-structured interview schedule, which comprised of 11 questions. This type of interview schedule was chosen as it allows for focused and more in-depth exploration, and is also compatible with both qualitative and quantitative approaches (Willig, 2008, p. 23).

Table 15 Interview schedule

1. Tell me about your current career and what it entails.
2. For how many years have you been in this career?
3. Tell me the story of how you landed in your current career.
4. What and who motivated you to choose a career in STEM?
5. Describe any difficulties you, as a woman, encountered in your career development.
6. What or who had contributed to your success in your career story? For example: People, skills, beliefs or anything else.
7. Do you think that the problems encountered by women in STEM careers differ from those encountered by their male counterparts?
8. Did you find it difficult, as a woman, to achieve success in your career?
9. How did you overcome those difficulties?
10. Which factors contributed to your decision to remain in / leave this field?
11. What have so far been the most enjoyable aspects of your professional career?

The interview schedule for the STEM and non-STEM groups was the same, except for one question that differed for the two groups, namely, “Which factors contributed to your decision to remain in this field?” (STEM-group) and “Which factors contributed to your decision to leave this field?” (non-STEM group). Interviewees often shared information that covered several questions in one discussion.

Face-to-face interviews were the preferred mode for the collection of qualitative data and most of the interviews were conducted in this manner. The researcher had to conduct one telephone interview because of the participant’s very demanding schedule, and three interviews were conducted by email for the same reason and also because of distance. Meho (2006) maintains that email interviews are as valid and appropriate as face-to-face interviews. Email interviewing has some advantages above face-to-face interviewing as probing and clarification can take place in a considered manner without the time pressure experienced in a face-to-face situation and allows respondents more time to consider their responses. The written form of these interviews also makes transcription unnecessary. Ethical considerations, such as confidentiality and anonymity, also apply to email interviews (Meho, 2006, p. 1288). It must be noted that it is an asynchronous process and that it differs from electronic surveys insofar as real communication between the parties takes place with sufficient opportunity for clarification.

Eleven interviews were conducted face-to-face and three interviews were electronics-based. The latter were necessitated by the participants’ availability, demanding schedules and/or distance. One respondent from the non-STEM group was only available for a telephonic interview. Most of the interviews were conducted in the participants' offices at their workplaces. The researcher travelled Cape Town, Hermanus, Pretoria and Johannesburg to conduct interviews with the participants who lived there. In order to put the participants at ease, the researcher always started with a request such as "Tell me about your current job."

The researcher transcribed a few interviews herself, but the majority was transcribed by a professional transcriber. The transcribed interviews were checked for accuracy by listening to the recorded interviews again and checked the transcriptions accordingly.

4.6.2 Quantitative data collection

In this section the qualitative data collection, as well as the measurement instruments and their properties will be discussed.

The purpose of the quantitative data collection process was to measure self-efficacy levels and to obtain information on women's education and work experiences, and their perceptions of barriers encountered by women who studied in the STEM fields. A measurement instrument was developed for this purpose. This part of the survey can be called the exploratory questionnaire. The following three self-efficacy scales were included: the New General Self-Efficacy Scale, the Occupational Self-Efficacy Scale and the General Self-Efficacy Scale. The three self-efficacy tests completed by the respondents will be described in terms of their psychometric properties and statistical characteristics. The questionnaire included a large number of items on barriers, motivation and STEM-related issues in education and work, which could be called contextual items. These issues were grouped according to the sections in the questionnaire and an overview of the section is provided in paragraph 4.6.2.4 below.

The questionnaires were distributed to several STEM- related institutions, as mentioned in paragraph 4.5.2 above, and the process was repeated after three months in order to increase the response rate.

Data was collected by means of a computerised questionnaire developed on the Qualtrics system (https://pretoria.eu.qualtrics.com/). This system, which is similar to the well-known SurveyMonkey (surveymonkey.com), was made available by the University of Pretoria as a data collection tool. Qualtrics allows for the use of a number of different question formats, enables confidentiality and also allows the researcher to determine whether one person has completed more than one questionnaire by listing the IP address. The results of the completed questionnaires can be easily exported to Excel and SPSS. It is also possible for respondents

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to complete part of the questionnaire and continue at a later stage. The pre-amble and questionnaire are included as Appendix B. The questionnaire was widely advertised, as mentioned in paragraph 4.6. Even twitter was used for this purpose and prominent women scientists and events were followed to encourage people to take part in the survey.

The explanatory questionnaire and three self-efficacy measurement instruments, i.e., the New General Self-Efficacy Scale, the Occupational Self-Efficacy Scale and the General Self-Efficacy Scale, will be discussed in the following section.

4.6.2.1 Measurement instruments

Reliability and validity are two of the most basic and important aspects of measurement that will be considered for the instruments used in the survey (Shadish et al., 2001; Whitley, 2002, p. 123).The reliability of a measure relates to its degree of consistency, which means that it ought to give the same results if it is applied to the same person in different circumstances. Validity refers to the degree of accuracy, meaning that it ought to measure only the trait that it was designed to measure (Gravetter & Forzano, 2012, p. 63; Whitley, 2002, p. 14). Self-efficacy was measured by using previously standardised instruments, while the psychometric properties of both these instruments, along with reliability, were reported for the Exploratory Questionnaire.

The complete survey is included in the Appendix B. The Exploratory Questionnaire (EQ) was largely based on the semi-structured interview schedule that was used in a previous study undertaken to investigate the reasons for the success achieved by women in SET careers (Maree & Maree, 2010; Maree et al., 2008). The information from that qualitative study was used to determine the closed questions for the EQ. The constructs involved in the questionnaires are mentioned below in the discussion of the instruments.

The electronic survey consisted of the following sections, which are discussed below:

a. Biographical information
b. Three self-efficacy scales
c. The Exploratory Questionnaire

4.6.2.2 Biographical information

Relevant biographical information relating to gender, age, place of residence, employment and level of education were included in this section of the survey. This information was required to contextualise the interpretation of the results.

4.6.2.3 Self-efficacy scales

The three standardised scales that were used to measure self-efficacy levels are the New General Self-Efficacy Scale, the Occupational Self-Efficacy Scale and the General Self-Efficacy Scale, which will be discussed below.

a. New General Self-Efficacy Scale (NGSES)

Bandura's (1977b) warning that self-efficacy should be measured within specific task contexts prompted the development of a number of context-relevant self-efficacy scales. Chen, Gully, and Eden (2001, p. 64), however, developed a scale enabling one to determine a general indication of a person's level of self-efficacy. Chen et al. (2001, p. 63) define general self-efficacy as "one's belief in one's overall competence to effect requisite performances across a wide variety of achievement situations*."* The specific self-efficacy measurements might measure a motivational state, according to Chen et al. (2001, p. 63), who further postulate that generalised self-efficacy indicates a motivational trait that is formed and developed through an accumulation of success and failure experiences: it "captures differences among individuals in their tendency to view themselves as capable of meeting task demands in a broad array of contexts" (Chen et al., 2001, p. 63; Scherbaum, Cohen-Charash, & Kern, 2006, p. 1049). This conceptualisation of general self-efficacy is ideal for this study: although the STEM status of the women in the sample might influence specific self-efficacy, i.e. career-related variables, it is possible that they will not differ on generalised self-efficacy. Women in non-STEM careers could have a high level of generalised self-efficacy, but a lower level of career-related self-efficacy. The possibility also exists that, due to the experience of "failure", women in the STEM field incorporate these experiences in a generalised self-efficacy trait.

The NGSES, which was developed and validated by Chen et al. (2001), consists of eight items that examine factorial dimensionality, content validity, reliability and predictive validity. Previous studies showed that good results were obtained. On different occasions, reliability yielded alphas of .85 and .86 (α) and a test-retest of .86 (r). These reliability coefficients were confirmed in other studies (Culbertson, Smith, & Leiva, 2010). Steele-Johnson, Narayan, Delgado, and Cole (2010) confirm the construct validity of the measure. In the NGSES, a five-point Likert scale was used with the following anchors: Not at all true (1), Hardly true (2), Somewhat true (3), Moderately true (4) and Totally true (5).

Examples of two items are:

1. I will be able to achieve most of the goals that I have set for myself.
2. When facing difficult tasks, I am certain that I will accomplish them.

b. Occupational Self-Efficacy Scale (OSES)

Schyns and Von Collani (2002) developed a generalised scale of self-efficacy related to occupational processes. The task-specific self-efficacy scale used by Betz and Hackett (1981) was deemed too narrow as it focused on very specific areas (Lucas, Wanberg, & Zytowski, 1997; Rooney & Osipow, 1992). In the current study, it might be useful to utilise a test in the occupational domain, which is somewhat broader than, but not quite as broad as generalised self-efficacy (e.g. The NGSES and GSES). The factor structure and internal consistency reliability (α = .87) were determined and were found to be good (Schyns & Von Collani, 2002, p. 234). A focus on occupational processes would also accommodate different careers and specialisations. The test has two versions (a longer and shorter version with 20 and eight items respectively), which show a high correlation (r = 0.95) (Schyns & Von Collani, 2002). Konig, Debus, Hausler, Lendenmann, and Kleinmann (2010, p. 238) found internal consistency to be .79 for the shorter form.

Example items are:

1. When I make plans concerning my occupational future, I can make them work.

2. One of my problems is that I cannot get down to work when I should. (R)

The OSES formed part of the survey and can be seen in Appendix B.

The response categories for the scale are: 1 = Completely true, 6 = Not at all true. This was adapted to the following to fit with the other tests: Not at all true (1); Hardly true (2); Somewhat true (3); Moderately true (4); and Totally true (5).

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c. The General Self-Efficacy Scale (GSES)

The third and final scale used in the current study was the General Self-efficacy Scale (GSES) developed by Schwarzer and Jerusalem (1995). According to Rimm and Jerusalem (1999, p. 330), the GSES “can be conceived of as a personal resource or vulnerability factor that may influence people's feelings, thoughts and actions … People with a high sense of efficacy trust in their own capabilities to master different types of environmental demands.” The reliability and validity of the GSES was confirmed by a study involving respondents from 25 countries (Scholz, Doña, Sud, & Schwarzer, 2002), in which reliability ranged from .86 to .91 (Argyropoulou et al., 2007, p. 321; Scholz et al., 2002, p. 246). The factor structure was stable and validity was sufficient. Overall Scholz et al. (2002, p. 249) conclude that “… the present research supports the assumption that general perceived self-efficacy is a unidimensional and universal construct.” The validity and universality of the construct is supported by the study conducted by Luszczynska, Gutiérrez-Doña, and Schwarzer (2005). Despite criticism of the generalised scales including the NGSES, Scherbaum et al. (2006), in an item-response study, concluded that the validity, reliability and item function of both the GSES and NGSES are good. The NGSES performed better than the other generalised scales they investigated in respect of item discrimination, item information and relative efficiency of the test information function (Scherbaum et al., 2006, p. 1059). Evidence was found for the stability of the generalised self-efficacy construct across languages and cultures (Luszczynska et al., 2005; Scholz et al., 2002).

The General Self-efficacy scale comprises 10 items answered on a four-point scale: the response format was 1 = Not at all true; 2 = Hardly true; 3 = Moderately true; and 4 = Exactly true, but was again adapted to Not at all true (1); Hardly true (2); Somewhat true (3); Moderately true (4); and Totally true (5).

Two sample items are:

1. I can always manage to solve difficult problems if I try hard enough.
2. If someone opposes me, I can find the means and ways to get what I want.

The complete GSES can be found in the electronic survey in Appendix B.

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4.6.2.4 Exploratory Questionnaire (EQ)

Based on the semi-structured interview schedule and the findings of Maree et al. (2008), the 94 questions in the EQ were formulated to cover a series of topics. The items were categorised under the following headings:

a. Motivation for STEM studies
b. Factors contributing to remaining in a STEM career
c. Role models motivating to engage in STEM studies
d. Other influences on decision to embark on a STEM career
e. Influences on decision to embark on STEM studies
f. Barriers in tertiary studies
g. Barriers in work environment
h. Overcoming barriers
i. Overcoming difficulties
j. General questions 1
k. General questions 2
l. Societal expectations
m. Progress in women's careers

In their research, Maree et al. (2008) focused on the changing perceptions of women in SET and their career histories in South Africa. The purpose of their research was to interview women who were established and had high profiles in the SET field, focusing on the factors that contributed to their professional success.

The EQ is attached as Appendix B. The purpose of the questionnaire was to explore the women's motivation for embarking on studies in STEM fields and their experiences while studying and later in their work environments. It also included questions relating to factors such as obstacles and how barriers were overcome in their STEM careers.

The Likert response used ranged from 1 to 5: Never (1); Rarely (2); Sometimes (3); Often (4); and All of the time (5).

The following are examples of items included in the questionnaire:

To what extent did the following factors contribute to your decision to remain a professional in this field?

- I enjoy my work.
- I receive acknowledgment for my expertise.
- I am regarded as an expert.

4.7 Data analysis and inferences

The parallel convergent design utilises triangulation and allows the researcher to separately collect and analyse quantitative and qualitative data on the same phenomenon. The results are converged during the analysis. Researchers use this model when they want to compare results or to validate findings (De Vos, 2011, p. 447). According to Bryman (2012), working with two sets of different forms of data and interpreting them in a meaningful way can be difficult. Mixed-method data analysis implies the combination of statistical and thematic data-analytic techniques (Teddlie & Tashakkori, 2009, p. 8).

4.7.1 Qualitative analysis

The qualitative analysis will be discussed in this section. Bartley, Beddoe, Fouché, and Harington (2012, p. 249) explain analysis as an attempt to reduce data to an intelligible and interpretable form "so that the relations of research problems can be studied and tested, and conclusions drawn." Answers to research questions are not found in the analysis, but by interpreting data and results. Thematic analysis was used to analyse the data.

4.7.1.1 The transcription process

Each interview was transcribed as soon as possible after meeting with the respondents. According to Willig (2008), the transcription alters the interview data from spoken to written language. The interviews were transcribed verbatim. The written transcriptions made it possible to analyse the data and look for trends and patterns. This process of transcribing was the connection between the collection and analysis of the data as it made the data accessible for analysis.

The next step was thematic analysis, which is described in the following section.

4.7.1.2 Thematic analysis

Thematic analysis is a largely neutral approach to organising verbal and related material into patterns or themes, as found in the data (Braun & Clarke, 2006, p. 79). It is neutral in the sense of being used by a range of theoretical and paradigmatic approaches to do a particular job. Epistemologically, two approaches can be followed when using thematic analysis, namely a realist[13]/essentialist approach and a constructionist approach (Braun & Clarke, 2006, p. 85). The latter is aligned to what is classically understood as qualitative approaches, namely discourse analysis, narrative analysis and grounded theory. The former approach, namely the realist approach, is typically used when one is interested in the distribution of themes and subthemes. This study moves between the realist and constructionist approaches as the interpretation of themes goes beyond the surface of appearance (Braun & Clarke, 2006, p. 81).

Braun and Clarke (2006, p. 84) distinguish between two levels of analysis, namely the semantic (or explicit) level versus the latent or interpretative level, which corresponds with the realist/constructionist approaches. Usually when thematic analysis is restricted to surface meanings and theme frequency, a realist approach can be assumed. However, the aim of thematic analysis is to go beyond description and, depending on the theoretic-methodological position, it can be combined with, for example, discourse analysis or grounded theory (Parker, 2015; Wertz, 2011). The epistemological position then changes the aims and outcomes of the thematic analysis. Onwuegbuzie et al. (2009, p. 131), clearly working within the realist approach and advocating mixed-methods, argue for a similarity between thematic analysis and factor analysis.

Braun and Clarke (2006, p. 83) point out that there are two directions of coding for and finding themes in textual and related data, namely theoretically driven and inductive thematic analysis (Frost & Shaw, 2015, p. 380). The former utilises structures and themes acquired from literature and theoretical propositions, thus conceptually a framework guides the finding of themes. The latter is a bottom-up process insofar as the themes are revealed or discovered in the text without a preconceived position guiding the coding. However, Braun and Clarke (2006, p. 84) point out that a completely a-conceptual approach is not possible as the research already commences with data collection from a preconceived notion of what the researcher would like to find and investigate. However, approaches to thematic analysis advocating the

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[13] Braun and Clarke (2006, p. 80) understand realism as naïve realism that merely gives voice to the speakers in the text. It is also essentialist as opposed to constructionist.

avoidance of the literature overview in order not to contaminate the data with preconceived ideas can also be found in discussions of thematic analysis.

In this study, a combination of the two abovementioned approaches was used. First, the researcher read the transcript to obtain an overview of the interview. Following this, general notes were made about the interview before it was reread and the researcher wrote general notes and comments. The researcher then started coding the text and looking for words and themes. This process was repeated several times. Themes were identified in the next phase of revisiting the interviews. Additional patterns that related to women in science were then identified in the interviews. Thus one can say that a second-order analysis yielded themes not related to social cognitive theory, but explored the elements related to women engaging with science studies and careers.

Table 16 shows the steps Braun and Clarke (2006, p. 87) propose for doing a thematic analysis. They maintain that a thematic analysis can be done in various ways and that there is not necessarily a correct or wrong way. However, their framework is useful for this study and any changes made by the researcher in the process of coding and interpreting themes will be indicated.

The first step in the framework below is intended to allow the researcher to familiarise herself with the data. Steps 2 and 3 show that coding is an important part of the analysis process (Miles et al., 2014). It is not merely a data-preparation step, but along with showing that coding can be directional it allows the researcher to start looking for patterns. The type of coding used in this study can be called descriptive coding, i.e., description of behaviours, combined with protocol coding (Miles et al., 2014). The latter involves a pre-established coding system which, in this case, comes from the theoretical constructs to be identified and examined during the interviews. Step 3, or the search for themes, can also be called a second-cycle coding to allow for the identification of broader patterns and themes, and codes are grouped together (Miles et al., 2014).

The themes can be visually represented as a network of themes and codes, but could also be combined with a narrative representation and discussion (Miles et al., 2014). In a narrative description with supporting evidence from the interviews, some interpretation is also required.

Step 4 involves the reviewing the themes and a further investigation of patterns not apparent during the first round of analysis. These interpretations in the form of claims and propositions form the basis for making conclusions about the data. This is followed by defining and naming

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the themes, as mentioned in Step 5 of Braun and Clarke's framework. Each theme needs to be refined and names have to be generated for them. The final step in this framework is the finalising of the research report.

As can be seen in Table 16 below, the researcher added an additional column to Braun and Clarke (2006, p. 87) model to described her process of thematic analysis in relation their steps.

Table 16 Steps in thematic analysis (Braun & Clarke, 2006, p. 87)

Phase	Description of the process	Process followed by researcher
1. Familiarising yourself with your data:	Transcribing data (if necessary), reading and re-reading the data, noting down initial ideas	After each interview the data was immediately transcribed. To ensure the accuracy of the transcriptions, the researcher read each interview immediately after transcription, while the interview content was still fresh in her mind. Once all the interviews had been conducted, she re-read them in order to obtain a comprehensive view of the contents and started making general notes on issues that might be relevant / important.
2. Generating initial codes:	Coding interesting features of the data in a systematic fashion across the entire data set and collating data relevant to each code	2.1 The researcher preferred to do hand-coding and marked related words and phrases using different colours. For example, words or phrases that referred to obstacles were all marked in red. 2.2 This process was repeated six times until the researcher felt satisfied that she had a good grasp of the interviews and was beginning to discern emerging themes.
3. Searching for themes:	Collating codes into potential themes and gathering all data relevant to each potential theme	3.1 After this step, the researcher identified key words, phrases and patterns. She then categorised these into themes that were reflective of the data set.
4. Reviewing themes:	Checking if the themes work in relation to the coded extracts and the entire data set	4.1 The researcher revisited the data several more times to ensure that the categories and themes were as accurate as possible.
5. Defining and naming themes:	Ongoing analysis to refine the specifics of each theme, and the overall story told by the analysis, generating clear definitions and names for each theme	5.1 The data was again revisited and evaluated for its usefulness and relevancy. 5.2 It was also clear to the researcher that certain themes, such as self-efficacy and agency, were very interrelated and could not easily be clearly separated.
6. Producing the report:	The final opportunity for analysis. Selection of vivid, compelling extract examples, final analysis of selected extracts, relating back to the analysis of the research question and literature and producing a scholarly report of the analysis	6.1 The final analysis is presented in Chapter 6. 6.2 The content of the interviews was analysed based on the constructs as presented in the social cognitive theory. 6.3 The qualitative and quantitative results were assessed and evaluated in terms of the initial research question posed in this study.

Table 17 contains the strategies for reaching conclusions suggested by Miles et al. (2014). It should be sufficient to say that inferences and claims made about data need to be adequate and must be substantiated. The strategies to be used involve comparing trends across the two data sets and results to look for differences and similarities. The presence of "outliers" is important whether in observations, statements or meaning. Even statements and trends that are not typical can be important for interpretation. The principle of triangulation must be kept in mind and meaning can be revealed by comparing and contrasting accounts. The researcher responded to Miles et al.'s approach as seen in Table 17 by adding **comments in green** to indicate the process she followed.

Table 17 Approaches for generating meaning, checking data quality and explanations (Miles et al., 2014)

Tactics for ensuring the basic quality of the data and critically checking explanations
Data quality can be assessed through checking for representativeness. (1) Checking for researcher effects: Researcher bias was avoided by using transcriptions rather than notes only. (2) Triangulating across data sources and methods: **Researcher used a mixed-methods approach.** (3) Weighting the evidence, deciding which kinds of data are most reliable: Looking for repetition in themes and replication of themes across the two data sets (4) Looking at "unpatterns", checking the meaning of outliers, using extreme cases: **Investigating each data set and results** (5) Following up surprises: Formulating possible explanations (6) Looking for negative evidence: Comparing the results of two data sets (7) Ruling out spurious relations: Comparing the results of two data sets (8) Replicating a finding: Comparing the results of two data sets (9) Checking for rival explanations: Comparing the results of two data sets (10) Checking explanations by getting feedback from participants: If possible, contact participants, which can be difficult in the case of a quantitative study

In the following section, the quantitative analysis is discussed. This will include the aspects of the quantitative analysis such as data collection, data preparation and cleaning, analysis, statistics, data reduction, modelling and ensuring the quality of analysis and interpretation.

4.7.2 Quantitative analysis

Quantitative analysis is discussed in this section. Data analysis is a very important part of the research process and precedes interpretation. The quantitative data is analysed using a range of descriptive and inferential statistical procedures. The first step is the conversion of the raw data to a useful form for analysis. The main aim of data analysis is to address the research question(s) (Creswell & Clark, 2011, p. 206). This will be done through steps in the quantitative analysis that unfold in a linear way (Creswell & Clark, 2011, p. 204).

These steps are:

a. Data collection
b. Data preparation and cleaning
c. Analysis
    - Descriptive statistics
    - Inferential statics
    - Data reduction
    - Modelling
d. Ensuring the quality of analysis and interpretation

The researcher describes the process of qualitative data analyses according to the four abovementioned steps. The first step in data collection will be discussed in section 4.7.2.1 below.

4.7.2.1 Data collection

Quantitative data collection was discussed in paragraph 4.6.2 above and included data collection by means of the survey, which consisted of biographical information, the self-efficacy scales and the Exploratory Questionnaire.

4.7.2.2 Data preparation and cleaning

Data was regularly downloaded from the Qualtrics survey at two-day intervals. The survey was closed after a period of eight months as no further responses were received. Severely incomplete questionnaires, duplicate response sets (such as when a person starts completing one survey, but later continues with another) and practise data were removed so that only 108 of the original 146 respondents remained. Data was checked for inconsistencies, such as coding errors (which ought not to happen due to the range one can specify in the electronic survey) and improbable data (such as age and gender – no males were supposed to complete the survey.

Missing data was discovered and the researcher managed it as follows: The completeness of self-efficacy scales was checked and those that were incomplete had to be completed. Missing values on the exploratory survey could be overlooked, but for factor scores and similar exercises it was possible to input averages without skewing the data. Biographical data had to be reasonably complete since issues such as age, field of work, whether they were active in the STEM field or had left it could not be guessed. Fortunately, the sample of 108 had mostly full values any missing values, even if they were small, were reported in the results report.

The next step was the data analysis, which is discussed below.

4.7.2.3 Analysis

In this section the presentation of descriptive information, inferential statistics, data reduction and modelling are discussed. All analyses where done with SPSS Version 24.

a. Descriptive statistics

Descriptive statistics involve information regarding the means, distribution, range and related aspects of variables. Biographical and demographic information, as provided in frequency tables, along with means and related statistical descriptors where required. Extensive information, such as that contained in distribution graphs, was indicated in the appendices. Demographic information was largely presented as contingency tables by cross-tabulating with STEM status (i.e., whether a person had remained in STEM or had left STEM). Where additional information was required to clarify issues, additional cross-tabulations were done.

Data distributions and normality were checked and were reported where appropriate. The reliability coefficients (Cronbach Alpha) for the self-efficacy scales were determined, as well as the psychometric properties of these scales (Pallant, 2011, p. 6).

b. Inferential statistics

In this instance, inferential statistics involves inferences regarding group differences in a number of variables. Two groups were identified in the study, namely the women in STEM and those that had left STEM. The variable is called STEM status. Two independent sample tests were done to determine group differences, i.e., the STEM group and the non-STEM group were compared for significant differences in the self-efficacy questionnaires discussed in paragraph 4.6.2.3 above and the factors of an exploratory principal component analysis (CFA) (paragraph 4.6.2.4). Because the one group was much smaller than the other (n = 88 and n = 20) allowances were made for possible skew distributions due to the non-random selection of both samples (Field, 2013, p. 275). Skew distributions and sample size may require more robust techniques, for example when comparing groups (Wright, London, & Field, 2011). It is possible to choose between nonparametric tests and bootstrapping, although the nonparametric tests are based on ranks (e.g. when comparing groups using the Mann-Whitney U-test) (Pallant, 2011, p. 227) and the bootstrap simulates sampling distributions based on the raw data. Despite the sample sizes some of the variables under consideration were normal to approximately normal distributions, thus enabling parametric calculations.

A bootstrap was done for each independent sample test comparison over and above the t-test. The specifications of the bootstrap can be seen in the relevant sections of Chapter 6. Values for differences, significance values and confidence intervals for differences were determined (Field, 2013, pp. 364-375). The main index for robustness is the 95% confidence intervals for the differences between groups. The confidence interval should be either positive or negative and should not cross 0 or have 0 as one side of the interval. If this is not the case, no confidence can be placed in the values found in the comparison, i.e., that the differences between groups are true rather than contingent.

c. Data reduction

Data reduction involves finding a number of factors that express the commonality between a large number of items. One part of the survey, the Explanatory Questionnaire (EQ), consisted of 94 items about the different issues listed below, which can be called contextual STEM-related issues:

a. Motivation for STEM studies
b. Factors contributing to the decision to remain in a STEM career
c. Role models who provide motivation to engage in STEM studies
d. Other influences on the decision to embark on a STEM career
e. Influences on the decision to embark on STEM studies
f. Barriers in tertiary studies
g. Barriers in work
h. Overcoming barriers
i. Overcoming difficulties
j. General questions 1
k. General questions 2
l. Societal expectations
m. Progress in women's careers

Although the items in their original groupings were examined in Chapter 6, it was deemed sensible to reduce the number of items to groups of items that showed high degrees of correlation and could reveal commonalities (Pallant, 2011, p. 181). The reason for this was that some items across the questionnaire could correlate and form meaningful constructs or factors. Usually an exploratory factor analysis is done to determine factors. For such a factor analysis, or in this case an exploratory principle component analysis (PCA) (Pallant, 2011, p. 182), factor size and the item-sample size ratio are crucial (Pallant, 2011, p. 183). As previously mentioned, the sample was not very large (N = 108). Field (2013, p. 684) states that small samples need not preclude factor analyses, especially if communalities are larger than .6. Furthermore, indices such as the determinant of the R-matrix, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's Test of Sphericity were checked (Pallant, 2011, p. 192). The requirements for these indices are:

a. The determinant of the correlation matrix should be larger than 0.00001 to indicate that no multicollinearity is present (Field, 2013, p. 686).
b. The Kaiser-Meyer-Olkin measure of sampling adequacy ranges from 0 to 1. The closer the value is to one, the better: it means that distinct clusters of items can be formed and factor analysis could be appropriate (Field, 2013, p. 684). Closer to zero means that the correlations between items are diffused, but values from .5 should be adequate.
c. Bartlett's Test of Sphericity indicates whether the correlation matrix is significantly different from the identity matrix, i.e., the latter indicates low or no correlation between variables. A significant value indicates that the correlation matrix is not an identity matrix. If it is not significant, correlations might be too small (Field, 2013, p. 685).

All the analyses employed the Varimax rotation with Kaiser Normalization (Pallant, 2011, p. 185). Although one might expect the factors to correlate somewhat, the aim was to find distinct clusters of items; thus this rotation would force factors to be uncorrelated so that component structures could be clearly shown. It must also be noted that the focus is on the patterns found in the current sample without trying to generalise. The reason for this orthogonal rotation is to yield a simple component structure, i.e., items should not load too much on more than one factor.

The number of items compared to the sample size was equal – thus a ratio of almost 1:1. In such a situation it is inadequate to do only one PCA. One could have started with the grouping of items as found in the survey and only explored those groupings or packets of items. However, realising that some issues such as barriers and even motivational items might show high correlation, a PCA specifying a few factors was done to gain a sense of the clustering of items. These packets were then factor analysed and explored on their own. The first analysis was thus akin to inspecting a correlation matrix and using groups of correlating items to do a PCA; thus it can be regarded as a practical heuristic to facilitate PCAs on packets of items.

Four PCAs were done and the number of factors was determined based on the scree test, namely, the inflection point of the plot of eigenvalues (Pallant, 2011, p. 184). The eventual rotated factor structures were evaluated on the basis of item loads with loadings of .4 and higher taking precedence. Items with low communalities, or those that did not make psychological sense when they showed low loadings or communalities, were deleted. The components were then labelled based on the contents of the items. These components can be called constructs and their internal consistency of Cronbach Alpha estimates was determined.

d. Modelling

The aim was to construct a model of constructs (based on the components from the exploratory PCAs) along with the total scores of the self-efficacy scales in order to determine the ability of the model to classify participants into STEM and non-STEM groups. The assumption is that their perceptions and self-efficacy scores probably would allow one to determine aspects responsible for their group membership. Having a binary response variable, namely membership of either group, and a number of continuous independent variables, would make a logistic regression appropriate (Pallant, 2011, p. 171). Again it should be noted that the sample size is small and the groups are not equal in terms of size, even though most of the variables were approximately normal. A model would indicate the weight of each variable that can contribute to predicting group membership, and the odds ratio of indicating the likelihood of belonging to a group (Field, 2013, p. 787). The adequacy of the model would be indicated by the overall multiple correlation, a significant change in -2LL Chi-square as variables are added or subtracted, and the significance of each variable's contribution by the weight and Wald statistic (Field, 2013, p. 784; Pallant, 2011, p. 177). The classification table (in Chapter 6) would show the success achieved by the model in classifying the participants.

4.7.2.4 Ensuring quality of analysis and interpretation of data

The quantitative research design can be called comparative or relational, depending on the type of analysis executed. When comparing the STEM groups, the differential designs are also an analysis of relationships. For instance, the question "Does the STEM groups differ on self-efficacy scores?" can be reformulated as "What influence does STEM status have on self-efficacy scores?" or even "What is the relationship between STEM-status and self-efficacy?" Both the differential and correlational designs describe relationships between variables.

By asking questions about relationships between variables it is easy to ask how the relationships explain each other, or whether the one causes the other. Questions such as the following are then posed: "Do levels of self-efficacy explain or influence one's eventual decision to remain in or leave STEM?" It is clear that this study cannot answer causal questions, although this might be the eventual aim of similar studies. Causal and explanatory

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hypotheses can only be answered by means of experimental designs, or at most quasi-experimental designs. Both designs call for the manipulation of the independent variable, which in this case is lacking. Quasi designs need not have random assignment to groups as is required by experimental designs, and preferably both designs should require control groups (Shadish et al., 2001, p. 14).

In this analysis construct validity and statistical validity are important. Although their control ensures better causal inferences, the exploratory and comparative analyses the study wants to make eventually still depends on valid construct measurements and valid and appropriate use of statistical tests.

Most of the requirements for the statistical techniques were dealt with in the previous section (4.7.2.3) and relate to sample size, linearity, normality and distribution shapes, not doing many t-tests without adjusting the exceedance probability level, and adhering to the requirements of statistical techniques such as t-tests (independence of observations, homogeneity of variance), PCA and logistic regression (Shadish et al., 2001, pp. 42-53). In all instances a decision must be made to utilise distribution-free or non-parametric tests, or parametric tests. The level of measurement of variables must be taken into account (ordinal or interval, binary or continuous). The details, where appropriate, were specified in Chapter 6.

Construct validity is another important issues that might influence interpretation, thus what variables are called, what they supposedly measure and how reliable their measurement is along with validity indices (Shadish et al., 2001, pp. 72-74).

4.7.3 Integration of data and results

Creswell (2012, p. 55) notes various ways to combine the results of data of parallel convergent designs. They are: quantifying the qualitative data, qualifying the quantitative data, comparing results, or consolidating data. The first option codes the qualitative data and, by using frequencies, compares the coded themes with the quantitative data. By qualifying the quantitative data a factor analysis is done, the factors become themes and these are compared with the qualitative data. Direct comparison makes use of, for instance, trends in both data sets to confirm or disconfirm findings. When consolidating data, the two data sets are combined to form new variables, or are compared in a table to see similarities or differences between results (Creswell, 2012, p. 551).

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4.8 Ethical considerations

Ethical considerations in research are critical and forms a major element in research. In this study the researcher adhered to the aims of the research in order to promote the pursuit of knowledge and truth which is the primary goal of research. She focussed on imparting authentic knowledge in this study.

The researcher conducted the research, in an environment of trust, accountability, and mutual respect for the participants. The researcher adhered to the following code of conduct, namely, honesty in reporting data as well as data analysis and data interpretation, objectivity in the sense of avoiding bias whilst doing the research, respect for intellectual property and non-discrimination. The researcher valued integrity and acted responsibly with openness and valued every participant's contribution towards the research (Creswell and Clark, 2011, p.179).

The participants were informed about the aim of the study and how the information will be used, and were required to sign a consent form (Appendix C). They were also assured that participation was voluntary and that they would be free to terminate their participation at any stage. Their anonymity was ensured and they were assured that the data would be regarded as confidential. Any identifying characteristics would to be removed from any published information and data would be stored for 15 years in the Department of Psychology at the University of Pretoria. Ethical clearance was obtained from the Faculty of Humanities.

4.9 Conclusion

In this chapter the methodological approach was discussed along with the research design, sampling method, data collection, data analysis and integration. Since a parallel convergent mixed-methods design was to be used, the qualitative and quantitative parts of the study would proceed more or less simultaneously. The analysis of the two parts would be done separately and would only be compared and integrated at the end of the process. The purpose of using this approach was to determine from different perspectives what the role of self-efficacy is in either keeping women in STEM careers or causing them to leave. The initial assumption was that women's levels of self-efficacy can explain why they remain in or leave STEM careers. The qualitative part of the study involved interviews with 15 women in and out of STEM careers, while the quantitative part involved an extensive survey completed by 108 women who included some in STEM careers and some who had left the STEM field.

The qualitative results of this study will be discussed in the next chapter.

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CHAPTER 5
RESULTS: QUALITATIVE DATA

5.1 Introduction

This chapter reports on the qualitative empirical research undertaken for this study and the findings based on the data. The findings will be guided by the theoretical framework of the Social Cognitive Theory, as discussed in Chapter 3.

As a reminder, the research problem for this study was:

> *What is the role of self-efficacy in the different career trajectories of (a) women who remained in the STEM field for at least three; and (b) women who trained for STEM careers but who chose not to stay, or decided to leave the field for some or other reason?*

As an introduction to the to the discussion, brief reference will be made to the methodology, as discussed in Chapter 4, in order to contextualise the discussion of the results obtained through the analysis of the qualitative data.

5.2 Sampling

As mentioned in section 5.1, a mixed-method approach was chosen for this research as it focuses on collecting, analysing and mixing both quantitative and qualitative data in a single study. The sampling discussed in Chapter 4 will be briefly summarised.

5.2.1 Sampling method and process

A purposive sample strategy was followed. Two groups of women were identified by word-of-mouth referrals and by advertising/enquiring at several STEM institutions. Purposive sampling, rather than a random sampling strategy, was chosen as a sample with unique characteristics had to be identified. The second reason for using purposive sampling was the difficulty of identifying both STEM and non-STEM career women. It was assumed that women who had studied in STEM fields and were employed either in or outside the field would know others in similar situations. Despite this strategy it was difficult to find especially women who had studied in the STEM field and had left the field for some or other reason. A number of women who had left STEM was identified, but were not prepared to participate in interviews. Both groups were also asked to complete the surveys on Qualtrics, as discussed in Chapter

4. The results of the survey are discussed in Chapter 6, which focuses on the quantitative data.

The researcher focused specifically on women in the STEM careers in which they were considered to be most 'scarce'. As discussed in Chapter 4, the respondents included women in careers in the following fields, in which they are generally poorly represented: mechanical engineering, electric and electronic engineering, aerospace engineering, civil and chemical engineering, physics, astronomy, meteorology, geology, mathematics and several categories of natural scientists. This study attempted to include women from these categories. The sampling inclusion criteria for the women with whom qualitative interviews were conducted were discussed in Chapter 4.

5.2.2 Summary of the research participants' profiles

The mean age of the STEM group was 42.4 years (SD = 16.02). Their ages varied from 30 to 78 years. The mean age of the non-STEM group, who were between the ages of 41 and 48 years, was 44,8 years (SD = 2.64).

The participants' areas of specialisation are listed in Table 18.

Table 18 STEM and study careers of realised sample (N = 15)

Group	Participant number	Area of specialisation
STEM	1	Electronic engineering
	2	Laser science (physicist)
	3	Geography: specialisation in cultural and socio-political geography and geography of gender
	4	Ionospheric physics (space): Space science
	5	Nuclear physics
	6	Civil (structural) engineering
	7	Mechanical engineering
	8	Applied mathematics and physics
Non-STEM	1	Geology
	2	Quantitative genetics
	3	Chemical engineering
	4	Mathematics
	5	Agriculture science
	6	Civil engineering
	7	Electronic engineering

Three of the participants in the STEM group had doctoral degrees and one was a professor. A further three had completed master's degrees and two had BSc degrees. The non-STEM group included two participants with master's degrees and one with an honours degree, while the rest had basic STEM degrees.

5.3 Data collection

The semi-structured interview schedule (see Table 3 below) contained eleven questions and was used as a guide for the interview. Although this was discussed in Chapter 4, it is repeated here for the sake of the discussion of the interviews.

Table 19 Interview schedule

1.	Tell me about your current career and what it entails?
2.	How many years have you been in this career?
3.	Tell me the story how you landed in your current career?
4.	What and who motivated you to choose a career in STEM?
5.	Describe any difficulties you encountered as a woman in your career development?
6.	What contributed to your success in your career story? For example: Which people, skills, beliefs, etc.?
7.	Do you think that women in STEM face different problems from those encountered by their male counterparts?
8.	Did you, as a woman, find it difficult to achieve success in your career?
9.	How did you overcome these difficulties?
10.	Which factors influenced your decision to remaining in / leave this field?
11.	Which aspects of your professional career has so far been the most enjoyable?

The semi-structured interview schedule for the face-to-face interviews was based largely on an interview schedule that had previously been used in a study that investigated the reasons for the success achieved by women in STEM careers (Maree & Maree, 2010; Maree et al., 2008). However, the following two questions were added:

a. Which factors influenced your decision to remain in / leave this field?
b. What have been the most enjoyable aspects of your professional career so far?

The semi-structured schedule was used to interview a sample of fifteen women.

The process of preparing for and conducting the interviews was discussed in Chapter 4 and can be summarised as follows:

a. Introducing the researcher and the research project
b. Completion of consent form
c. Completion of biographical information
d. Permission to record the interview

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Table 20 below contains a summary of the researcher's personal impressions at the end of each interview. These impressions formed part of the analysis process and provided the researcher with an opportunity to reflect on the interview. Table 20 enabled the researcher to identify some trends that were evident during her conversations with women from the two groups: the STEM women were vocal about the difficulties they encountered, but appeared to be resilient, i.e., they were women who could persevere in the face of obstacles. Non-stem woman almost invariably justified their leaving STEM by referring to their responsibilities towards family and children. It seemed as if some of these women were somewhat reluctant to discuss their career trajectories. One respondent was clearly restrictive in her conversation.

Table 20 Researcher's personal impressions based on interviews that dealt with salient points

Participants	Researcher's personal impressions based on the interviews and important issues for the researcher		
	Researcher's impressions	**Important issues to remember**	**Any suggestions by the participant**
A (STEM)	Participant A had very difficult experiences in the STEM field, but is resilient and is determined to stay on.	The participant started talking again after the recorder had been switched off and shared some important information. "And often one thinks the wise road is the easy road, it is not."	The participant was of the opinion that women scientists should be good role models by showing that they were competent.
B (STEM)	Participant B was dyslexic she was determined to overcome this problem.	Mind-set is important.	If you work hard, anything is possible.
C (STEM)	Participant C was divorced and had young children to care for.	Strong gender focus	Women are strong and have to persevere.
D (STEM)	Participant D was young and had a lot of drive She had wanted to study for a BSc degree, but had to choose certain subjects at school.	Not many women in this field Commitment: long road ahead to get to field of interest	There will be obstacles in the way – there is no smooth sailing in life. You just need to know where you can get help.
E (STEM)	Participant E was very proud to be a female engineer and was very determined to make a success of her career.	Very focused on finishing what she had started	Women should not try to be men. Stand your ground as a female.
F (STEM)	Participant F had a lot of support while studying engineering, but experienced difficulties when she started working as an engineer. She created the impression that she was in a hurry and the researcher felt she should not draw out the interview unnecessarily.	She took pride in her work.	Endurance is very important.
G (STEM)	Participant G was very committed to her work and also very committed to her children.	Sees obstacles as opportunities Good planning is necessary	Cannot change career because you are female.
H (STEM)	During the email interview with Participant H the researcher felt that although it was not as satisfying as a face-to-face interview, she nevertheless obtained information.	The participant's attitude towards everything was so positive that the researcher was a bit sceptical.	Females are in the minority and have less competition in the workplace, which makes things easier for women.
I (N/STEM)	It seemed to the researcher that Participant I "blamed" her gender as the reason for not pursuing a career in science.	Some women might create their own obstacles.	Women should have access to bursaries.
J (N/STEM)	Participant J was convinced that a STEM career and a family do not work well together.	Jobs that offer a flexible structure are important (half days)	Importance of a flexible structure.

Participants	Researcher's personal impressions based on the interviews and important issues for the researcher		
	Researcher's impressions	**Important issues to remember**	**Any suggestions by the participant**
K (N/STEM)	Participant K was extremely busy and the interview had to be rescheduled a few times. The telephone interview was very rushed as K was busy.	STEM is a male environment.	
L (N/STEM)	Participant L chose another career because she wanted to work more with people. The interview was difficult as she seemed to be reluctant to share.	The researcher found it strange that a person would do postgraduate studies in a field in which she did not want to work. The participant said that she wanted to work with people, but was reluctant/shy during the interview.	Women can be successful in any career of their choice.
M (N/STEM)	Participant M had small children and had to leave her career.	She was initially very invested in her career and completed a master's degree in a STEM field.	
N (N/STEM)	Participant N had small children and had to leave her career.	Interest in the STEM field is important.	
O (N/STEM	Participant O had small children and had to leave her career as her husband's career was much more important than her own.	Family is everything and traditional gender roles are still important.	

5.4 Analysis approach

The qualitative and quantitative data were collected separately. For the qualitative part of the study, thematic analysis was used. Specific steps were followed to identify themes in the data. Before the analysis, the data (transcripts) were organised into two groups namely, STEM and non-STEM. The researcher read and re-read the interviews to familiarise herself with the content of the transcripts. In the process of exploring the data, notes were made on the transcripts. The approach in this instance was to search for specific information in the data. The salient themes pertaining to self-efficacy were identified after the literature survey and were then systematised and used as a code list with broader themes and finer details as subdivisions. However, using a top-down process (i.e., a theoretical or conceptual approach) did not preclude the identification of any additional aspects and themes while the interviews were being analysed. As the researcher's understanding of the self-efficacy phenomenon and related constructs deepened, the interviews were reworked and further details and/or more themes were added. Points that stood out were identified and coded, and categories (of themes) were formed and interpreted. As discussed in Chapter 4, Braun and Clarke (2006), as well as Creswell and Clark (2011), summarised these steps as follows:

a. Familiarising yourself with the data
b. Generate initial codes
c. Searching for themes
d. Reviewing themes
e. Define and name themes
f. Reporting

The researcher followed the above steps and summarised the process of data analysis in the discussion in Chapter 4 (see 4.7.1.2).

The contents of the interviews were analysed based on the theoretical framework, as presented in the social cognitive theory discussed in Chapter 3. Bandura (1995b, p. 235), amongst others, provided relevant theoretical interpretations of his work on women in professional non-traditional female careers, and Hackett and Betz (1981) established that self-efficacy is a more powerful trait than interest, values and abilities when it comes those careers (Bandura, 1986). Lent and Brown (2006a) added constructs such as outcomes expectancy (person's subjective probability that *his or her performance* of a behaviour will be followed by a particular outcome), interest, career choice and decision making, goals, persistence, contextual support and barriers and satisfaction.

5.5 Themes

The categorising of the qualitative data resulted in twelve broad themes and thirty-three subthemes. The qualitative data were presented according to themes and subthemes. The twelve broad themes were the following: the display of self-efficacy, the display of agency, career decision making, display of resilience, sources of self-efficacy, family life, personal barriers, work barriers, educational barriers and motivation to remain in / leave a STEM career. The 33 subthemes were linked to the main themes and are indicated in Table 21, along with brief descriptions.

Table 21 Themes and subthemes

Theme number	Theme	Description	Subtheme
1	Self-efficacy	The belief that one has the capability to do certain things	Judgement of own ability Reaching goals Willingness to perform tasks
2	Agency	Intention to act, willingness and energy to act	Intentionality (intention to act) Self-reflectiveness (self-regulation)
3	Career decision making	Making choices with regard to study fields, which careers to follow and which jobs to choose	Academic performance Career choice Career performance in job
4	Resilience	The ability to persevere in the face of obstacles	Recovery from disappointment or obstacle Persistence
5	Outcomes expectancy	Expecting certain reactions as a result of performing certain actions	
6	Family life		Motherhood Marriage Balancing personal life and work-life
7	Work barriers	Obstacles experienced in the STEM work environment	Male-dominated environment Lack of promotion, acknowledgement, salary
8	Sources of self-efficacy		Mastery experiences (own attempts to control environment) Vicarious experiences (seeing something done by someone else) Supportive experiences (verbal/social persuasion) Emotional experiences (physiological and emotional states that accompany actions)
9	Education barriers	Both school/ tertiary educational obstacles	Tertiary: Lecturers discouraged girls Tertiary: negative classroom environment

Theme number	Theme	Description	Subtheme
10	Personal barriers	Obstacles and difficulties at home	Doubting own ability Family issues No support structure
11	Motivation to embark on STEM studies/ career		Motivation and support by parents Personal interest Siblings Family Teachers Other external people
12	Leaving STEM	Any consideration to leave STEM	No longer finds it interesting Marriage and children Wants to work with people

As can be seen in Table 21, the twelve broad themes include motivational constructs, motivational individuals and events, and barriers at school and in the tertiary education and work environment. Family life, which is the one barrier that would fall under personal barriers, is indicated separately. The motivational constructs draw exclusively from the social cognitive theory and include self-efficacy, outcome expectations, resilience, agency and career decision making. Career decision making is not so much a motivational construct as one that relates to both motivational and career issues.

The subthemes indicate finer detail under each construct or theme. For example, self-efficacy has the following subthemes: assessment of own ability, reaching goals and willingness to do tasks. Each of these subthemes exhibit some form of self-efficacy, as discussed in Chapter 3. This should be distinguished from outcome expectations, which include beliefs about the outcomes of specific forms of behaviour. One may have certain outcome expectations, but they may or may not lead to self-efficacy. However, self-efficacy assumes some form of outcome expectation.

In section 5.6 below the data will be summarised and represented in matrix form to facilitate analysis and interpretation.

5.6 Data representation

This section contains a summary of Themes 1 to 12. The first matrix (Table 22) summarises Themes 1 to 7.

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5.6.1 Themes 1 to 7

The themes self-efficacy, agency, career decision making, resilience, outcome expectations and family life are presented in a matrix in Table 22. The respondents are listed vertically and the themes horizontally. The STEM respondents are listed first, followed by the non-STEM respondents. The respondent letters (A, B, etc.) are kept in the same order for all the reported tables in order to facilitate comparison. The table provides the most salient point for a particular theme. For instance, respondent A mentioned goal achievement and a positive belief about her own abilities as the most prominent issues under the theme self-efficacy. The same respondent showed strong persistence and an attitude of fighting back, but also showed strong outcome expectancies. Where a cell is left blank, no prominent point expressing the particular theme could be found. The narrative discussion of the table can be found in the next section.

Table 22 Summary of Themes 1 to 7

Participant	Theme 1 self-efficacy	Theme 2 Agency	Theme 3 Career decision making	Theme 4 Resilience	Theme 5 Outcome expectancy	Theme 6 Family life	Theme 7 Work barriers environment
A (STEM)	Reaching goals Assessment of own abilities	Intentionality "Stubbornness"	Career choice Academic performance	Persistence Fighting back	Strong outcome expectancy	Married	Men feel threatened by strong women Chauvinist manager As a female you should be competent
B (STEM)	Reaching goals Never doubting own abilities	Intentionality from young age Self-reflection	Career choice: wants cutting edge Academic performance	Recover from disappointment – . persistence	Important to use opportunities	Married	"Oh it is because I am a girl", it really didn't pass my mind."
C (STEM)	Willingness to take up tasks Judgement of own abilities	Perseverance and determination	Career decision making Academic performance Career choice	Recover from disappointment or obstacle – persistence	Strong outcome expectancy	Divorced	Gender important in career
D (STEM)	Reaching goals Judgement of own abilities Willingness to take up tasks	Intentionality, self-reflection	Academic performance very important Make difficult decisions to reach goal	Persistence	Strong outcome expectancy		Single
E (STEM)	Judgement of own abilities	Intentionality Self-reflection Set own targets	Career choice Job performance	Persistence	Strong outcome expectancy	Single mother	Excels in career because she is a woman Acknowledges that males dominates the environment
F (STEM)	Academic performance Career choice Judgement of own abilities	Intentionality	Academic performance Career choice Job performance	Persistence	Strong outcome expectancy		Have to stand your ground in predominantly "male" environment
G (STEM)	Willingness to take up tasks Judgement of own abilities	Intentionality Career choice	Career choice	Resilience Persistence	Strong outcome expectancy	Had to plan family, which can sometimes be challenging	Proud to be a woman and finds it motivating

Participant	Theme 1 self-efficacy	Theme 2 Agency	Theme 3 Career decision making	Theme 4 Resilience	Theme 5 Outcome expectancy	Theme 6 Family life	Theme 7 Work barriers environment
H (STEM)	Willingness to take up tasks Judgement of own abilities	Intentionality Career choice	Job performance	Resilience	Strong outcome expectancy	Left career when children were born. but returned after a couple of years	Did not find that being female was an obstacle
I (N/STEM)	Did not show self-efficacy in STEM, but clearly saw herself as successful in her current career	She was convinced that being female was the reason she could not progress	Career decision was based on her brother's recommendation	Obstacles made her leave STEM – no demonstration of persistence	Did not show outcome expectancy		Did find that being female was an obstacle in STEM
J (N/STEM)	She did not experience a science career as "practical" and believed that it was not structured to suit women. Women should be caretakers.	She did not reveal attributes such as agency during the interview.	She sees herself as successful in her current job "because it is easy."	She referred back to her position in a SET industry where she was allowed to work half days. She said, "If it hadn't been for that, I would have left long ago."		Family life and motherhood are very important and she saw women as caretakers	She did not feel discriminated against on account of being a woman.
K (N/STEM)	Although participant K realised in the early stages of her studies that she had chosen the "wrong" career, she finished her degree and worked in the field for several years. The researcher regards this as an indication of self-efficacy.	Strong agency. Started later in life to study for another career.	Career was not what participant expected, but she continued for several years	Strong resilience	Outcomes expectancy in terms of new career	Family life and work life can be difficult to manage.	She had experienced being a woman as very difficult in her STEM career.

Participant	Theme 1 self-efficacy	Theme 2 Agency	Theme 3 Career decision making	Theme 4 Resilience	Theme 5 Outcome expectancy	Theme 6 Family life	Theme 7 Work barriers environment
L (N/STEM)	Did not show self-efficacy in STEM (didn't even enter STEM), but clearly saw herself as successful in her current career		Did not enter STEM field, even though she completed an honours degree in mathematics	Very low career resilience	Unclear		Gender not an issue
M (N/STEM)	Worked for recognition	Showed agency in that she looked for alternative ways to be with her children	Academic performance	High resilience to fulfil role as mother	Unclear	Family life and motherhood are very important, but "I often look at the successful women and I think to myself: What did you have to sacrifice in order to be where you are?"	
N (N/STEM)	Judgement of own abilities	Showed limited agency in STEM career	Very good academic performance Doesn't see herself as successful in career : she talked about "convincing" herself for the career	Not much resilience: did not want to fight with people.	I tried to imitate my father in what I was doing.	Motherhood and family life are more vital and career is secondary.	She experienced being a woman in a STEM career as very difficult because of the lack of provision for mothers with small children
O (N/STEM	Judgement of own abilities "High in demand"	Agency	No much was revealed in interview	High resilience Returned to career after long break	Good – sees herself as competent	Motherhood and family life are important	Being female is a positive factor in STEM environment

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5.6.2 Theme 8: Sources of self-efficacy

The self-efficacy sources are summarised in Table 7. These sources are mastery experiences, vicarious modelling, verbal support and emotional and physiological experiences. The same stipulations as discussed in paragraph 5.6.1 above apply. For example, respondent E showed expressed strongly feelings about vicarious experience, i.e., she found that seeing other women working in STEM was inspiring.

Table 23 Summary of Theme 8: Sources of self-efficacy

Participants	Sources of self-efficacy			
	Mastery	**Vicarious**	**Verbal / Support**	**Emotional/ Physiological experiences**
A (STEM)	Showed strong attempts to control own environment			
B (STEM)	Showed strong attempts to control own environment Worked hard at every opportunity.			
C (STEM)			Supervisor played an important role	
D (STEM)	Showed strong attempts to control own environment			
E (STEM)		Seeing people doing it: motivation But as you go along you do find people that motivate you. When you look at them… I would say I was… I did a diploma, I did not go to varsity and then I changed as I went on and then I did my degree in varsity.	Lecturer played an important role	I only look at the things that would build me. I used to focus on that
F (STEM)		Vicarious: family of engineers Emotional experiences		
G (STEM)	As a woman in an engineering world you must keep your head up. You must always push forward and prove yourself			
H (STEM)	Showed strong attempts to control own environment Worked hard at every opportunity.			

Participants	Sources of self-efficacy			
	Mastery	**Vicarious**	**Verbal / Support**	**Emotional/ Physiological experiences**
I (N/STEM)		Brother was an engineer		
J (N/STEM)		Father was a scientist		
K (N/STEM)				
L (N/STEM)	Mastery			
M (N/STEM)		Family of engineers family of scientists		
N (N/STEM)		Father inspired her to become an engineer		
O (N/STEM	Mastery: control environment			

5.6.3 Themes 9 to 12

Table 24 contains a summary matrix of Themes 9 to 12. Theme 9 comprises educational barriers, i.e., obstacles experienced by women at school and/or tertiary level. Theme 10 refers to personal barriers. Themes 11 and 12 refer to women's reasons for remaining in leaving STEM careers.

Table 24 Summary of Themes 9 to 12

Participant	Theme 9 Educational barriers	Theme 10 Personal barriers	Theme 11 Why stay?	Theme 12 Why leave?
A (STEM)	Participant A experienced gender-related education barriers		I am doing a good job. I want to build a career [in STEM].	
B (STEM)		Had a learning problem as a child	Enjoyed the work, really liked making use of opportunities and was working very hard at it	
C (STEM)		Single mother with two children	Enjoyed the work, enjoyed challenges	
D (STEM)			Found work interesting and wanted to build a career	
E (STEM)			Saw the work as: *Really, it is a challenge that I enjoy*.' Many highlights at work – when experiments are successful.	
F (STEM)			Enjoyed the technical side of the job.	

Participant	Theme 9 Educational barriers	Theme 10 Personal barriers	Theme 11 Why stay?	Theme 12 Why leave?
G (STEM)		Child care could be difficult as working hours were not flexible	Enjoyed and was motivated by the challenges of the job	
H (STEM)			Loved technical side of job. Enjoyed solving real- life problems and developing infrastructure	
I (N/STEM)	Could not obtain a bursary for tertiary studies on account of her gender	Financial problems		Did not get support because of her gender
J (N/STEM)		Found office hours difficult because of child-care needs		Environment was not family friendly
K (N/STEM)	Difficulties in class because she was the only woman			Needed more career stimulation
L (N/STEM)	No proper science teaching			Wanted to work with people
M (N/STEM)		Found office hours difficult because of child-care needs		Left because of motherhood and marriage and family commitments
N (N/STEM)		Experienced trauma, but did not want to share details		Left because of motherhood and marriage and family commitments
O (N/STEM		Gender stereotyping		Left because of motherhood and marriage and family commitments

The issues presented in this section are discussed in narrative format in the following section. The themes are discussed in numerical order, i.e. from 1 to 12.

5.7 Analysis of qualitative data

This section contains a narrative representation of the themes and subthemes presented in the previous section. The experiences of the fifteen women are discussed in the order in which they appear in Table 22, Table 23 and Table 24.

5.7.1 Theme 1: Self-efficacy

The extent to which participants displayed self-efficacy is discussed in this paragraph and each respondent's own assessment of her ability to achieve something or exhibit certain

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related behaviour will be identified. This includes aspects or subthemes such as willingness to perform tasks, sense of accomplishment and achievement of goals. The subthemes are indicated in bold in the text below.

Participant A talked about her experience in a well-known company where she worked as an electronic engineer. Despite experiencing very hostile behaviour, she stayed on. She said:

> *But perhaps my career would have been easier. I have no idea. But I really tried to find out what is the wise thing to do there so I stuck around and it was not the easy road. And often one thinks the wise road is the easy road, it is not.* ***(Goal achievement)***

Despite the difficulties experienced, she remained focused on her goal, which was to be an engineer. This showed persistence, which is an important component of resilience. She also showed her commitment and this directed her behaviour so that she could remain in her job despite difficulties. She confirmed her positive assessment of own ability **(self-efficacy)** by saying: "*Ja, I did do good work. Really, there is no doubt in anybody's mind that the work I did was good.* She continued in the interview and said *"It might be so that men are generally better in engineering and science, I don't care. I am also good at it.*"

She therefore showed **self-efficacy** and **judged** her own abilities very positively.

Participant A continued with the following statement:

> *Who I am is not determined by what you think I am or what anybody thinks I am. I know who I am … And at school that is definitely what kept me going. And often that is what keeps me going. Like where do I need to be to have some purpose in life? And it is not about it being easy, it is about having purpose.*

She achieved her goals by motivating her decision as having a purpose. In contrast, Participant M in the non-STEM group shared how, throughout her work life, she looked for acknowledgement. She said:

> *That's what motivated me and now … but I think it's something that I had to work on, on myself that you know uh it's the same with parenthood … you don't get recognition in parenthood, so you have to, you have to overcome your ... I have to learn to live without recognition. The ones that I crave, that is not necessary.*

This can be interpreted as a lack of self-confidence and a search for external validation.

Near the end of the interview Participant A said:

> *And that is one of the reasons I hang around; I present an example of a decent human being, being in engineering, being a female, being truly female, being competent, so that they see that and don't find it foreign* ***(judging own capabilities as part of self-efficacy)****. So, when they are in the workplace, they don't find it foreign that somebody is competent.*

With this statement she referred to her being competent in her job and being a good role model for other women who may enter the field. She showed **self-efficacy** through the **achievement of her goals** and experienced a sense of accomplishment. Moreover, her experience of accomplishment was in the workplace. In this instance she had a positive experience, despite the difficulties that might be present for a woman in the workplace. Among peers and men she has a unique experience of fulfilment as a "*decent human being.*" Furthermore, she feels that she has accomplished something as a woman *in* the workplace, the place normally experienced as woman-unfriendly. It is also important to point out that this feeling of accomplishment is a *source,* i.e., an emotional and positive experience of self-efficacy.

Participant B confirmed her confidence in her own abilities by saying: "*So, I feel like I find my space okay, and if I haven't it is not because I doubt myself because I am a woman. I never doubt my capabilities.*" This participant had trouble with dyslexia in primary school and wanted to overcome this problem. She showed **self-efficacy** through her **judgement of her own ability** and was very focused on her **goals**. Participant B's struggle with her reading and spelling will be shared in paragraph 5.7.2 below

Participant C shared her commitment to her subject field. She had negotiated with education authorities to introduce her subject in high schools. She also introduced gender aspects into Geography and was the first student to do a PhD in gender and Geography. These initiatives were taken many years ago, before geography and gender were mainstream subjects. This participant was so convinced about her ability to make a contribution in her subject field and career that she started initiatives that displayed her **self-efficacy** and her **positive assessment of her own abilities**. She was also **willing to do the necessary work** in order to launch her subject field. This struggle continued and she said:

> *And we had another battle with our Geography, was that the education department put Geography in the Social Sciences. And we had to fight for the Natural Science components. And there was that conflict between Environmental Science and Geography, as disciplines … but we do bring that … together.*

This participant also showed **resilience** by actively campaigning for her profession despite opposition.

Another participant (Participant D) shared her ambition to become an astronomer. She experienced many obstacles but eventually, at the age of 29 years, was awarded a doctorate in Astrophysics. She showed **self-efficacy** by believing in her ability to achieve her goals. She displayed commitment in her determination to realise her envisaged career. She said: "*You just have to work, I guess, like in every other thing. There will be obstacles in the way, there is no smooth sailing in life."* This participant realised that she had to take extra subjects and even complete a postgraduate a degree to achieve her goal. She said: "*I would have to do physics and maths as my first degree and then later for honours and master's so, I can do astronomy or astrophysics."* She displayed self-efficacy, i.e. she believed in her ability to achieve her goals. Despite facing obstacles, she was prepared to complete undergraduate and honours degrees in order to become an astronomer. This showed not only **agency,** but also **resilience**.

Participant E displayed **judgement of her own ability** when she referred to her ability to do her work as well as any male scientist:

> *I will still be feminine, I will still be me. But I am going to do the very same job that they are doing, and I am not going to be beaten [bitter?] when they are saying the negatives right in my face, but I am going to do my job the best.*

She showed **self-efficacy** and believed that she could do the job as well as a male scientist. She continued by saying: "*Because at the end of the day you do not want to see yourself at the same place, you want to see yourself growing.*" For this woman growth and development was important and one way to do this was to view her work as a challenge – in this case the challenge to performing better than the men in the same job. It is possible that the growth derived from this process provided a fulfilling experience. Again it seems as if the experience of emotional fulfilment, challenge, development and growth provides a source for self-efficacy. The juxtaposition of this participant's experience of negativity with her determination to see the situation as a challenge might be an important clue to how successful women experience obstacles encountered in STEM careers.

Participant F **showed a willingness to work hard to achieve her goals**. She was busy with her master's degree in Engineering and she said:

> *I had to work hard, especially in my master's, I had to work hard … weekends as well. It is difficult again because … people that studied with me are very hard-working and conscience … we are very conscientious. You should be … [to finish your master's degree].*

This observation showed not only self-efficacy, but also agency to initiate action to achieve a goal and resilience to remain on the path that would lead to the achievement of her goal.

Participant I left her career in science because: "… *of the negative responses from the industry [as a female]."* She also left a second position because she did not have the support of her employers. However, this participant saw herself as very successful in her current career in administration. She said: "*So that, that scientific background has given me … uhm … an advantage maybe. In thinking logically and in, by think logically it's helped me, to advance to where I am, I am right, now* [in an administrative position]." This participant experienced **self-efficacy** in her current job, as is evident from the statement: "*I am [*in the right job*] right, now.*" When one compares the situations of Participants I and A, who both experienced difficulties because of their gender, it should be clear that their eventual responses to the situation differed. Participant A decided to stay in the STEM-field despite experiencing gender-related problems and showed several aspects of **self-efficacy,** such as **judgement of own ability** and **goal achievement**. Participant I decided to leave the STEM field because of the obstacles she had experienced, but showed **self-efficacy** in her current job. This comparison shows that two women might both have high levels of self-efficacy, but within different contexts. The question is: What makes the difference? One thing ought to be clear, which is that Participant I certainly did not experience the negative workplace as a challenge.

Participant N in the non-STEM group repeatedly referred to her academic achievements during the interview. She emphasised the fact that she was a high academic achiever but that she had left her career due to family commitments. She said the following:

> *I suppose I wasn't successful, if you take into account my working history. I know my father was disappointed that I didn't have the motivation to register as a*

professional engineer after I had left the profession and realised I had no intention of returning. She continued: Yes, interruptions of the career for family needs. I was aware that I felt incompetent after having been 'only' a mother for a few years – as if forgetting almost everything I had learned. I suppose I could again start working as an engineer if needed, but it would be a struggle to gain confidence in my skills. It would also destroy my enthusiasm for every new day.

Despite showing high levels of self-efficacy in terms of her intellectual ability, she did not show a similar level of self-efficacy with regard to her STEM career.

5.7.2 Theme 2: Agency

Agency encapsulates a person's ability and willingness to engage and act within her environment and context. One may regard agency as the opposite of passiveness or inability to control oneself and one's environment. Agency therefore has all the elements required for someone to exhibit self-efficacy. It might be that individuals who are passive and show a low sense of agency will also have low levels of self-efficacy. A person who has agency intends to act (intentionality) and plans to achieve goals (both forethought and goal-directedness). Participant B showed a high sense of agency when she shared her story about her relentless hard work and effort at school to be transferred to a mainstream class after having initially been in a remedial class due to her dyslexia. She worked so hard that she was transferred to a mainstream class and was soon one of the top students She related: "*So, I feel like I find my space okay, and if I haven't, it is not because I doubt myself because I am a woman. I never doubt my capabilities."* She displayed **agency** and a willingness to work extra hard to achieve her goals. She had been focused on her goals from a young age **(intentionality, forethought and self-reactiveness)**. During the interview she referred to getting an opportunity to study further:

Oh there is this opportunity and I am going to work really hard at it to see. So, it is really like taking opportunities and working very hard at it. Because then people are like 'You got your PhD in physics, you must be so clever', and most of the time I am like 'No, I just worked hard.'

Participant B showed several aspects of **agency** in her story about her battle with dyslexia and how she overcame it:

Also one of the things were I actually had to go to remedial classes when I was probably like 8 or 9, as I had issues with reading and spelling, I was a bit dyslexic.

> *And I kind of feel like, having that, made me realise if I just work hard I can actually overcome quite a few things* ***(intentionality)****. So I had to go to special classes when I was about 8 or 9, and then I was put back into mainstream classes. And when I was put back in I was quite stressed out because everyone around me is so clever. But at the end of the first term at school, I worked really hard and came like 4th in class or something* ***(forethought****). And I remember the teacher said this is really remarkable, you have come out of remedial and now in mainstream you have come 4th, so it kind of made me think, even my mom said consistent work pays off in the end. And I was like 'It does'. So think having those things growing up, it changes your mind-set as you grow up.*

She clearly exhibited intentionality and forethought that directed her behaviour. The same participant showed her agency **(forethought)** when she spoke about her career choice:

> *But I thought I would have a competitive edge, being one of a few. So, I would get an advantage, a whole lot of opportunities as opposed to if I were to choose a career where there are a lot of people already in that career.*

From this discussion it is clear that Participant B persevered despite enormous obstacles. She thus displayed a great deal of **resilience** by continuing until she achieved her goal.

Participant A worked in the industrial sector and was part of a team in which all the other members were male. The men tried to exclude her from the team. She said: "*Although, I was rather depressed afterwards, so I saw a counsellor and I also filed a grievance against my boss for that whole process … .*" Even though the participant was distressed about her situation at work, she showed **agency** because she did something about her situation. She went for counselling and afterwards lodged a complaint about the way she had been treated.

When Participant G started her studies in Engineering, she was totally surprised by the overwhelming number of men compared to women in this field. Her first reaction was: "*So I was like what am I doing here?"* But instead of identifying with the minority she decided that she belonged in this field. She said:

> *A lot of males, okay. You know that's the thing that encourages me, if there are a lot of males and less females, I need to make a change. I can't change a career because of a lot of males. I love it and I want to do it for myself. So that was my challenge.*

This participant found motivation that fueled her agency in the fact that she felt she belonged in the field despite being a woman. This experience of doing something about her situation helped her survive in a difficult study field and a male-dominated work environment. Later during the interview she said:

> *As a woman in an engineering world you must keep your head up. You must always push forward and prove [to] yourself that 'I can do this, I can do this'. It doesn't end up there, because once you keep quiet, uh you won't survive well … Because, I think it's a tradition, men they always have a tendency of saying 'We are men and she is a woman, so we head on'. So it's, it's, it's a very huge industry and strong industry and you have to keep your head up. Ja.*

This participant experienced a lot of challenges because of her gender and had to continuously prove her competence. She showed endless agency and displayed unbelievable **resilience** when she experienced discrimination on account of being a woman. She said: *"I love challenges. Ja, so that's what it keeps me going. I'm a woman, I'm alone and I'm gonna take this project up. Great. So it's quite good*!" This participant showed not only **agency,** but also **self-reactiveness and forethought** in the way she planned her career and family life. She acknowledged that it can be challenging to balance work and family, but one has to manage every situation as it arises. Again, as a woman she found the challenge motivating. It is as if the obstacles she was faced with – in this instance gender discrimination – motivated her and strengthened her agency. It must be noted that as in the discussion above, the challenge was supported by a feeling of belonging in the particular STEM career. It is possible that experiencing challenges is as important as the feeling of belonging in the career. Motivation originates from the tension that exists between these two constructs. In the process, she exhibited high levels of agency by striving to control the situation in a systematic and planned manner.

She further emphasized the importance of communicating with the work team: "To tell you the, the thing, you need to have a good communication with your boss and your colleagues. Once you get that one right, it's good. You stand up." Participant G was focused on **achieving her goals** in both her private and work life and managed to find a way to deal with problems/challenges.

5.7.3 Theme 3: Career choice

Brown and Lent (2016) maintain that career self-efficacy is displayed in aspects such as career choice and career satisfaction. Participant G was interested in a career in the "*machine world*."

In Grade 11 she had heard about engineering in her Vocational Guidance class. She understood that mechanical engineering involved "*somebody who's interested in, how does the thing work; machines and how to solve the problem on the machine and technology. I was like, yeah, then I want to be one. So, I ask myself where do I start?* While telling her career story, she mentioned that she had experienced obstacles, difficulties to balance work and family life, but stated that she was convinced that this was the career for her. She continued: "… *and this is where I'm going to stay."* After many years in her chosen field she still said: "*I'm going to specialise in it forever.*" This participant experienced high levels of **career self-efficacy,** which informed her choice of a STEM career. She acknowledged that she enjoys her career, which clearly showed that she experienced career satisfaction. In her conversation quoted above it is also apparent that career interest played a significant role. Her interest in engineering, satisfaction and enjoyment, despite the obstacles she had had to face, contributed to her remaining in her STEM career.

Participant B wanted a career in a field that was not "*very saturated*" and where she could have a "*competitive edge being one of a few.*" She said:

> *So, I would get an advantage, a whole lot of opportunities as opposed to if I were to choose a career where there are a lot of people already in that career ... leaving school I wasn't sure what career I wanted to go into, but my mom's advice was just take what you have enjoyed at school and something will come up with it. So, I really enjoyed maths and physics at school and I carried on with that, ja. So apart from enjoying it, I guess if you have an aptitude for a subject you enjoy it more. So, that is why I enjoyed those subjects.*

This participant made a **career decision** after having carefully considered the kind of career wanted, the subjects she enjoyed and her **academic performance**. The care with which she made a **career choice** contributed towards her **career self-efficacy**. Later in the interview she said: "*So, I feel like I find my space okay, and if I haven't it is not because I doubt myself because I am a woman. I never doubt my capabilities. It comes down to more of a personality thing than a gender thing.*"

This participant did not experience gender as a problem, she showed high levels of self-efficacy beliefs and acknowledged that she enjoyed and was interested in STEM subjects. Thus her experience of her capabilities and interests was congruent. These aspects contributed to her making a sensible career choice.

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Participant D was interested in astronomy but she first had to do an initial degree in Physics and Mathematics. She was so motivated that she decided to follow the "lengthy" road to get to her career of choice. She was deeply committed to her goal to such an extent that she completed her PhD in Space Science before she turned 30 years. Her career choice was based on an ability to envisage outcomes (or **outcome expectancy)** if executing certain actions. Obviously she had to have the capability and high levels of self-efficacy to maintain her **goals.** Her story supports Lent and Brown's (2006b) argument that outcome expectancy and goal orientation contribute to career self-efficacy.

Participant F chose a career in Engineering. She said*:*

> *Uhmm, I landed in engineering because I realised that there is a water supply problem in South Africa and especially in the rural communities. I really wanted to help. And engineering would have been the best way to do that. In rural communities, people are far away from water resources. They don't have access to clean water and clean water is a basic, basic thing. If you have clean water it changes things. The health of… you have healthy children and healthy families. The participant continued: From a very young age I enjoyed maths and I enjoyed physic part of science. I did not enjoy the chemistry part of it. I looked for a career that focused on my strong points.*

This participant made a **career choice** that is consistent with her **academic performance,** her **self-efficacy** and with her **career outcomes expectancy** which was to improve people's lives in a particular manner. Despite difficulties she experienced, she found her work satisfying and she said:

> *I am qualified in the field. I do not want to make a job change. I enjoy the technical side of things, I enjoy figuring out how to approach a problem. She continued to say "What really gives me satisfaction if I can give a report to a client and it looks professional and I can stand by it…that gives me satisfaction.*

Her **career choice** and **career performance** is clearly consistent with her **career self-efficacy** beliefs. One source of self-efficacy is enjoyment of what she does, over and above the contribution she wants to make in improving the conditions of the community.

In contrast to Participant F discussed above, Participant N left her career as engineer when she started her family because "*it felt like the right thing to do*." She did not return to her STEM career. She also stated that she chose the STEM field "*to imitate my father."* She continued later in the interview saying: "*I suppose I wasn't really successful… I know my father was disappointed that I didn't register as a professional engineer after I have left the profession and I realised I had no intention of returning*." She did not show career self-efficacy in terms her **career choice** and she did not experience **career satisfaction** in her career. One source of self-efficacy is modelling, and usually a parent or significant person provides the example. In this instance, her father was the role model but she does not frame it as modelling but "imitating" which, in a sense, is something devoid of integrity and substance. By using the word imitate she acknowledges that this was not her true calling. Thus, her career choice was misguided or not as substantial as one would expect from someone in STEM. What is worrisome is her choice of words for juxtaposing her family and STEM career: she says she left her career for her family because it felt like the right thing to do. This might convey the same sense as using the word imitate and might demonstrate lack of commitment towards her family as well.

Participant O also left her STEM career to take care of her children. She mentioned later in the interview that she could not go back to her career as engineer because of her husband's career which was the priority according to her. She did not view her career as a priority. At another stage, she said that she found it difficult to succeed in her career because of her family priorities. She stated that: *"certain women are more driven to be successful but somewhere they will have to give something up."* She did not show self-efficacy as an engineer because of her view that family priorities and a successful career in STEM are not compatible. Her **outcome expectancies** were focussed on her role within her immediate family.

Participant L left her career in science very early. She left the field of science because she was "*afraid that science would be dead to [her]*." She experienced little satisfaction in her job, which at that point impacted on her career self-efficacy. This remark illustrates the importance of the concepts of **persistence** and **satisfaction** in career self-efficacy. The assumption is that the more satisfaction one derives from one's career choices, the more likely one will be able to persist in a particular career trajectory. Satisfaction thus influences one's persistence, despite obstacles and difficulties, when striving to achieve one's career goals.

Participant H also left her professional career to raise her children, but her career trajectory differed from those of the previous two participants discussed. She had been out of the professional field for 12 years. When her youngest child started school, she decided to find work in the field of physics. She experienced her re-entry as "*easier [*than*] expected*." She also found her job "*satisfying'*. She later explained that she enjoyed working in the STEM field

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and applying her work skills to real life. She showed high **career self-efficacy, agency and commitment to her career choice.** She had believed that she would be able to successfully re-enter her professional field and did so. According to Lent's integrated model, as discussed in Chapter 3, this participant showed several aspects related to career self-efficacy. For instance, she showed **persistence** and **goal orientation** when she decided to return to her career and remained in the field. She also made use of support systems when she re-entered (**agency)** and found her colleagues to be supportive and "*encouraging*."

Participant J mentioned that she had left the STEM field because*:*

> *Science is not practical: To me a family is, my family is very important and I wouldn't … encourage my daughter to study … in science because it's not, very, practical to have, uh, to combine family and science ... the workplace is not built around women, … that women should be, caretakers, and the workplace is not actually built around that.*

This participant clearly did not regard her **career choice** to enter the STEM-field as a good choice. Another, Participant G, remained in the field, but mentioned how difficult it was to be pregnant and still keep in touch with her career development. Participant G continued*: "To go for maternity leave for four months, it's doesn't end up there. You have to take care of the kids. You have to be called from school."* She found combining family life with a career to be very difficult, but was determined not to neglect her career and said: "*I like being an engineer.*" Her commitment to her career helped her to overcome obstacles. This showed not only **commitment** to her career, but also **resilience** and **agency.**

Participant K mentioned that she had initially studied chemical engineering, but that it was not what she had expected "*In my mind chemical engineering had to do with chemistry. I thought it was chemistry related. Only to find that chemistry is one part of engineering*," she explained. However, she completed her degree and worked in this field for six years before making a change. She said that she was happy in her new career and also mentioned that she regarded engineering as a man's world. She said: "*I was the only woman. The only woman amongst men ... Wow, this is really a guy's environment*." Her **outcome expectancies** were initially not accurate and her **career decision making** was problematic from the start.

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5.7.4 Theme 4: Display of resilience

Resilience is a person's ability to overcome difficulties and misfortune. This was clearly illustrated by Participant E, who related how she continued with an experiment until it was completed. She said:

> *And then I will have my sleepless nights and spend my evenings here and going back home at about 3 am. Because I want to see the end-product and maybe you think 'No, you don't plan yourself well in advance'. No. I plan myself well in advance. I will take months to try and make the target. And most of the time those sleepless nights and so many hours in the lab, I get the final product. I get the final product and targets are not as easy as you think.*

This example shows her **persistence, and** also her **self-efficacy** and specifically **her willingness to perform the tasks** to ensure a successful outcome. She realised the importance of planning in advance (forethought) and this contributed toward her **agency** to do the job.

Participant E also mentioned that she came from a semi-literate family, which motivated her to excel. She said:

> *I think I would say, I was self-motivated, because from the family, the people that are illiterate. My parents, both of them, haven't finished, I would say primary [school]. And even with my uncles and aunts and grandmother, none of them, I would say are literate, although my parents they can read and write and communicate in English, but no one reached the grade, Standard 5, Grade 7 in my family. But I think I developed the passion for maths and science when I was in high school and I realised that one day I will be in this field.*

This participant decided to ensure that she received a proper education of her family's relative illiteracy. She overcame this difficult situation by striving to overcome illiteracy. Her educational environment could have hampered her progress, but she was inspired, persevered and in the end excelled in an area usually reserved for students from privileged backgrounds. The obstacles she had to contend with served as fertile ground for the development of her passion. In fact, she seemed to have developed and grown because of the barriers she had to overcome. One can illustrate the two ways obstacles can serve as motivation for better performance by formulating it as follows: some achieve despite obstacles, others because of obstacles. In the discussion of women exhibiting high levels of self-efficacy

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and agency in the face of barriers it seems as if in general it was the obstacles they faced that motivated them to excel. They did not merely develop high motivational levels and manage to achieve goals *despite* obstacles, but *because* of those obstacles. The obstacles therefore served as the feeding ground for their agency and self-efficacy. Participant A was an example of someone who developed determination and resilience because of obstacles. She made the following remark: "*I would rather take the stumbling blocks and maybe somewhere come out at top and be able to build a bit more of a career."* Clearly her resilience and achievement orientation were built on her experience of the challenges provide by obstacles.

Another example of resilience in the face of obstacles comes from participant F, who shared her experience as a female engineer. Her boss wanted her to take care of the company's administration because "*women are good with that."* She did not accept this and had to confront her boss numerous times before he would allow her to do site work. Her **persistence** paid off and she was eventually allowed to do the work for which she was qualified. Later in the interview she said: "*In a certain field there will always be obstacles. I think I have endurance … .*" She not only showed **resilience,** but also **judgement of her own ability** and **a willingness** to continue with a task despite the difficulties she encountered.

The question is whether the non-STEM group showed a lack of resilience by leaving their STEM careers. Does the decision to choose something other than a STEM career reveal a lack of resilience or something else? For example, Participant O left the field because of the demands of child care and said that "*children are always a problem when it comes to a woman and her career*." She also mentioned that she sometimes regretted her decision to leave the field, but was of the opinion that she would have to "*give something up*" if she decided to return to her work as an engineer. Could one regard a person who chooses family above a career as showing a lack of resilience, and did this participant **not show resilience** when established herself in her career performed well while in it? She was of the opinion that she had to "*give something up for her family*." However, some of the other participants, for example Participant G, said that they had to remain in the STEM-field because they had to provide for their families. However, Participant G's motivation was not merely monetary in the sense of having to work to provide for the family, as is revealed by the following statement: "*… I believe that there won't be any other career for me.*" She realised as a student that most of the other students in her field were male and thought: "*I can't change career because of a lot of males. I love it and I want to do it. So, this was my challenge.*" She later stated that as a woman in engineering, one has always has to prove one's ability: "*You must always push forward and prove yourself that you can do this."*

The contrast between her and Participant O is clear. Family life is difficult, but instead of making a choice, family as an obstacle became an energising challenge for Participant G. She was passionate about her work and enjoyed it. With this, she showed resilience. It seems as if resilience is not the stoic self-discipline required to persevere in hardship, but rather something related to passion and obstacles. The opposite of stoic self-discipline might be giving up. Thus, Participant O "*gave up*" because she lacked passion for the STEM field. A lack of resilience might mean a lack of passion (for something), which makes "giving up" an option. Maybe this giving up is merely yielding to another option. The choice between family and a STEM career is relatively easy if passion for either one is lacking.

Participant G's **resilience** in her career was evident again when she spoke about how difficult it was to be pregnant while continuing to work as an engineer: she **persisted** and succeeded in overcoming the obstacles. After mentioning some of the obstacles she had to overcome, she said: "*I have learned the hard way … and this is where I am going to stay."*

The development of resilience can also be seen in the stories of other participants, for example Participant D, who wanted to study astrophysics. When she applied for admission to the university, she was informed that this particular course was offered only at the postgraduate level. She realised that it would take several years to reach that level: "*I would have to do physics and maths as my first degree and then later for honours and master's*." When she entered the university, she did not have enough credits to qualify for an undergraduate BSc degree. She also did not qualify for financial aid. She was, however, accepted in the extended programme. She said*: "I decided that I was going to work very hard in order to finish my degree within the allocated time and do well enough to get sponsorships."* By the end of her second year she was one of the students on the Dean's Merit List. She continued studying to achieve her goal and at the age of 30 years completed her doctoral degree in Space Sciences. She worked hard, showed **resilience** and **achieved her goal,** even though it was a long and difficult road.

A final example of resilience is Participant C, who had a long career in science and experienced many difficulties. When she was still establishing her career, she was divorced. She had to build her career while also taking care of her two young children. She viewed obstacles as opportunities and she remarked:

> *I assessed them and I felt well, I did believe, that an opportunity came your way you say yes and then think about it. If you think, and-and you make a go of it.*

> *You've got to learn new things. I had to learn a-a lot of new things. And you've got to be, you've got to be open minded.*

She regarded the problems that she had experienced in her career as opportunities to learn and grow and said: "*And I did what I did for them* [children]." She showed **resilience** or the ability to overcome difficulties and misfortune because she was able to regard obstacles as challenges or opportunities.

5.7.5 Theme 5: Outcome expectancy

Outcome expectancy beliefs refer to the participants' identified expectancies or beliefs about behaviour that will produce specific outcomes. Participant A related that she had experienced some difficulties in her career as an engineer because of her gender:

> *The thing is, if you think about it, while I was studying you hear these things, you think right? You have to be a bit stubborn to stay around. Because there is many feedback … I have comments from colleagues saying "you are going to be an engineer, you must carry your own computer." It is ridiculous!*

As woman operating in an engineering environment, she expected certain outcomes.

Participant B also showed outcome expectancy when she referred to the opportunity to study further:

> *Oh there is this opportunity and I am going to work really hard at it to see. So it is really like taking opportunities and working very hard at it. Because then people are like "You got your PhD in physics, you must be so clever", and most of the time I am like "No, I just worked hard."*

She clearly expects hard work to have the desired outcome. As mentioned earlier, this participant had experienced a learning problem during her early school years, but had overcome it.

A third example is that of Participant D, who was mentioned earlier, and who had to study additional subjects to qualify for admission to the course of her choice and realise her dream of becoming an astronomer. She said: "*I would have to do physics and maths as my first degree and then later for honours and master's, so I can do astronomy or astrophysics."* She expected a positive outcome by doing what was required. Her outcome expectations were closely related to high levels of self-efficacy because she believed that she had the ability to achieve her goal. She also showed agency by translating her expectations or plans into action.

5.7.6 Theme 6: Importance of family life

The impact of family life cannot be ignored in this research. Many participants referred to issues around family life. Participant E, for instance, said:

> *As I said there were times where I needed to be in the lab to complete this project, if it is a target it is difficult. It is not that I am afraid to fail, I think it is because I am ambitious, I am someone that wants to complete whatever I started. And I will have a few hours with my kids; I am a mother of three kids. I have three children … but I normally, if I spend too much time there [laboratory] then I will make it up with them and say 'Let's spend … ', but I tried by all means that my work doesn't affect my family.*

She realised that her work had an impact on her family life and she tried to maintain a balance.

Participant N had excelled in maths and science at school. She decided to study engineering and graduated with distinction. She continued working as an engineer for a few years after her marriage. When she became pregnant she "felt" she had to dedicate herself to her children as her mother did and said "*it felt the right thing to do*." Later in the interview she mentioned that she had applied for bursaries as a student, but since she realised that she might get married and move to somewhere else with her husband, she took smaller bursaries that she could "work back" over a shorter period. It seems as if this participant never planned a lengthy career in engineering, but saw her future with a possible family. According to Brown and Lent (2006b), career self-efficacy is strengthened when a person shows outcome expectancy and goal orientation. This participant certainly showed these traits, but even though she stated that she had interrupted her career "*for family needs"*, her planning for the future was undoubtedly focused on her possible role as a wife and mother.

Participant O made a career choice based on her consideration of motherhood even when she was only in Grade 12. She was passionate about maths and science and wanted to become a doctor, but decided against a career in medicine "*because it will be demanding on a woman with children*." She then decided to rather study engineering. She eventually left her STEM career because her family needed her and she had to assist her husband in his career. She said that even though she believed in herself, she also believed that one has a

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responsibility towards one's children [and family]. This participant did not attempt to establish a career or to excel professionally and did not acknowledge any deliberate planning or goal orientation for her career. Her sense of agency was focused on her role as mother and wife. It almost seems as if she thought that a choice had to be made between having a successful career and being a good mother and wife. For this participant career and motherhood were opposites. She said: "*Some women are more driven to have success in their careers and they succeed, but somewhere they will fall shor*t."

Participant J commented: "*To me a family is, my family is very important and I wouldn't … encourage my daughter to study … in science because it's not, very, practical to have, uh, to combine family and science.*" At a later stage during the interview she said:

> *But it's-it's reality that somebody has to look after the family and I, … to me it's, I don't have my children to give them to somebody else to look after. So, it's always this balance. And you have either a career or you have a family, but you can't really have both.*

She mentioned that both her sisters were, and still are, in STEM careers, but the one does not have children and the other's husband takes care of the children. Once again, the idea surfaced that family care and a successful career are not compatible.

5.7.7 Theme 7: Work barriers

Several participants made comments about the work barriers in the STEM field and specific about the male dominated environment. This is in accordance with the literature as discussed in Chapter 2. Participant E, F, G, I, K and N mentioned how the science environment is not for women and that is it a "*guy's environment.*" Participant A said:

> *The Head of Department at that stage was a chauvinist; he tried to push me down, although I think he liked me as a person. He made many comments that made me realise he does not want to promote women strongly. So at some point I also stopped trying, honestly.*

However, participant E said:

> *… the field is male dominated mostly. Especially if there is a time for you to grow. I think that one kicks in and you get discouraged. As much as we are trying in the country, I do not think we are there yet. Because most of the females they are scared, "Am I going to cope?" that is the question you asked yourself in this male*

> *dominated field. I think it is all about fear, and I'd say with the experience I have I am supposed to be somewhere, and I always tell myself, 'If I was a male I would be somewhere'. Because I am a hard worker, but I think sometimes as a female it affects you. It affects you even if they receive the results at the end of the day.*

She continued by saying*:*

> *And I am like my place is not the kitchen. My place is where I am comfortable to be at. If it is in the organisation and I am comfortable and I am confident in what I am doing, I am not going to prove to the world that I am better. But I am going to do my best. Because at the end of the day you do not want to see yourself at the same place, you want to see yourself growing.*

With this statement, she took responsibility for the so-called male environment and positioned herself as part of the STEM-environment.

Participant F mentioned how her boss told on her first day at work that *"women are good with admin. So, you will get all the filing to do."* She did not accept this and confronted her boss several times until the situation changed. Participant G mentioned that she had challenged the "*male environment*" and that her aim was to be successful in her career because she also belonged there. She said:

> *As a woman in an engineering world you must keep your head up. You must always push forward and prove yourself that I can do this; I can do this. It doesn't end up there, because once you keep quiet, uh you won't survive well.*

Participant A said:

> *It is still, I think it is in the nature of the beast [male-dominated environment] and it will be for a very long time. It will be the case until there is 25-30% female representation in the field. The moment you are different, and that goes for all sorts of discrimination, the moment you are different from the rest of the group, the rest of the group of fairly homogeneous, so they believe because of the way they are, that is what makes them competent. And um, that might be so. .. I've had comments from fellow students that studied with me, that at some point, while we were studying, they made the comment that a woman in engineering is either not a woman or not an engineer'.*

However, she later added*:*

> *The thing is. If you think about it, while I was studying you hear these things, you think right? You have to be a bit stubborn to stay around. Because there is many feedback…I have comments from colleagues saying 'You are going to be an engineer, you must carry your own computer'. It is ridiculous, I did carry my own computer, but um, it doesn't make you an engineer or not an engineer! So ja, it is silly things like that. I remember when I was still, no I cannot remember when it was, in a lift, a lecturer made a comment: ' A woman may only cry twice in her career.'*

It is important to note that the participants mentioned above took responsibility to either adapt to the environment or change it, and did not accept the male-dominated environment as something that could not be changed. They showed agency and resilience and were determined to stay in their work environment.

In contrast, the participants in the non-STEM group thought that the male-dominated situation was a given and could not be changed, so that the only way to adapt to it was to become a man. Participant I shared several unpleasant incidents that occurred as a result of her gender: "*I was a woman. But obviously it was a disadvantage because then, your career development and your career advancement, was a bit stunted.*" Participant J said: *"Wow, this is really a guy's environment,"* and Participant M commented: "… *and, uhm, I think sometimes women become more uhm, more aggressive, more male, in order to succeed there are sacrifices. There are sacrifices that you have to do in order to be successful*."

Participant A experienced workplace barriers and shared her story about how difficult it was for her to be promoted as follows:

> *I was appointed there in the position as a Specialist, Technical Specialist. I have done good work in my position. Then I was promoted after a bit of a battle to Assistant Manager for Radio Network Optimisation. Then the manager for Radio Network Optimisation left, and I acted in this position for 16 months. When the position was opened up, they appointed someone else."*

She added:

> *That is not nice at all. I did a fairly good job. When I left there I was actually acting in many positions. I tried while I was in that position for 16 months to appoint people permanently to assist me, that was a very draining process."*

She was totally overlooked for promotion. She explained: "*And there were some other people too who weren't really at ease to take authoritative guidance from a woman.*"

5.7.8 Theme 8: Sources of self–efficacy

Under the theme sources of self-efficacy, the four sources, namely mastery experiences, vicarious experiences, supportive experiences and emotional experiences, were explored in the interviews.

5.7.8.1 Mastery experiences

As mentioned in Chapter 3, **mastery experiences** refer to activities that are mastered by the individuals after several attempts. This experience of mastery or accomplishment contributes to self-efficacy, i.e., to the belief that one can actually execute or do a specific task. Participant B, who had just won an award for best scientist the day before our interview, described her trajectory as follows (note that this quotation was discussed in another context above):

> *Also one of the things where I actually had to go to remedial classes when I was probably like 8 or 9, as I had issues with reading and spelling, I was a bit dyslexic. And I kind of feel like, having that, made me realise if I just work hard I can actually overcome quite a few things. So I had to go to special classes when I was about 8 or 9, and then I was put back into mainstream classes. And when I was put back in I was quite stressed out because everyone around me is so clever. But at the end of the first term at school, I worked really hard and came like 4th in class or something. And I remember the teacher said this is really remarkable, you have come out of remedial and now in mainstream you have come 4th, so it kind of made me think, even my mom said consistent work pays off in the end. And I was like 'It does'! So, think having those things growing up, it changes your mind-set as you grow up.*

This example illustrates how the respondent, through her own attempts and efforts, gained control over her environment and handicap. She overcame an obstacle through perseverance, but most of all she experienced a sense of accomplishment. This experience informed the belief that if she could do this, other things might also be possible. This is a very good example of a **mastery experience** as a source of self-efficacy, and the participant's story also demonstrates her **resilience** and **agency**.

The same respondent, Participant B, answered the question "Describe any difficulties you encountered as a woman in your career development" as follows:

> *'Oh it is because I am a girl,' it really didn't pass my mind. It was more like 'Oh there is this opportunity and I am going to work really hard at it to see'. So it is really like taking opportunities and working very hard at it. Because then people are like 'You got your PhD in physics, you must be so clever,' and most of the time I am like 'No, I just worked hard.'*

She ascribed her success to the fact that she had worked **hard and had mastered her environment**. She showed that she believed in her own ability to execute a job. She clearly showed that her **self-efficacy** beliefs had informed her **judgement of her own abilities**.

It is very telling that the non-STEM participants did not mention examples of mastery, or refer to mastery experiences as a source of self-efficacy. This does not mean that they did not have mastery experiences, but suggests that if they had indeed had such experiences, they were suppressed in favour of providing reasons why they chose an alternative route, namely to care for their families and children. It is of course possible they had never had positive mastery experiences in their STEM careers, but it would be difficult to reach a final conclusion in this regard. Mastery experiences might also have been present in their alternative careers, or if they cared for families they might have derived satisfaction from this. It is interesting to note that the STEM group make much of their enjoyment of their work. It almost seems as if the STEM career is so important that they did not consider choosing between family and career, but rather tried to maintain a balance between the two.

5.7.8.2 Vicarious experiences

Vicarious experiences or social modelling refers to seeing someone performing certain tasks or activities that show the observer that it is possible to execute them. Acting as a model for others then becomes a source of inspiration and increases self-efficacy beliefs.

Participant F was motivated by **vicarious experiences** to follow a career in STEM. She mentioned:

> *Also from my mother's family, her brothers were engineers and so my grandfather. So, I come from a family of engineers - if I can say that. … I definitely think because my family is in engineering it made a difference.*

Her career choice was based on her vicarious experiences. She had experienced a difficult time while working on site, but she continued despite hardship. She also showed resilience in her work environment and is currently very successful in her career.

Participant E shared her learning process by saying:

> *… you get motivated as well by people that you encounter in life, while I was in service trainings and training in companies, I used to look at those people that are already there and I would ask them how they got there.*

She clearly maintained her motivation to continue in her job (**vicarious experiences**) by observing others and asking advice from her peers and seniors.

When the researcher asked Participant D whether she felt discriminated against because of her gender, she replied:

> *… generally speaking I don't think so, because, for instance, my supervisor was a female and she was a respected researcher. For both my master's and PhD supervisors were women. And when I came back here, my boss who was a scientist, was also a female. So, I didn't really have to fight any harder just because I was a woman.*

She had had **positive social modelling (vicarious experiences)** experiences and therefore did not believe or have the perception that it is harder for women to be successful.

Participant J, one of the women who had studied in the STEM field but never worked in this field, stated that she had become a scientist because her father was a scientist. She had grown up in a family of scientists and her siblings were also scientists. Note that in another part of the interview she stated: "*My family is very important and I wouldn't … encourage my daughter to study … in science because it's not, very, practical to have, uh, to combine family and science."* With this statement she actually negated the value of **vicarious learning and social modelling.** She further commented that the (science) workplace is not suited to a woman's role as a caretaker. Even though social modelling was initially motivated her choice of a career in science, it was not influential enough to keep her in the field.

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Participant I in the group that never entered science careers, related her **vicarious experiences** as follows:

> *I'm the third of three children and I have two older brothers. Uhm they both in the science field, but specifically my second brother, is a mechanical and aeronautical engineer, okay. So, when I was choosing my subjects in high school, I chose, well Maths, Physics, uhm Geography and … Biology, with the intention of going into geology. So, I … then applied to the University of … for a BSc specialising in Geology, and that's how my, my choices evolved. It was a lot of influence from both my brothers, and my parents to an extent, but especially my second brother.*

Her brother's career choice motivated her to study in the STEM-field. This participant also described her mother as her role model. Her mother was an administrator and when the participant left the STEM field, she also took up an administrative position. She shared her story as follows:

> *My mum was a legal secretary for many years. Uhm, she was a kind of role model when I hit that dip where they said, uhm, my career was ending because they couldn't provide for me. So, I went into admin looking at my mum, as a role model. So definitely, my mum.*

This participant still has a very successful career in administration. It is interesting to note that the significant role model in her life eventually influenced her to enter an administrative career, possibly for the same reasons that STEM incumbents who had modelled themselves on significant other had entered the science field. It must be pointed out that although it seemed as if the participant's brother played a role in her choosing a STEM a study field, this type of modelling does not really qualify as vicarious modelling. The latter should increase feelings being able to do something (very similar to "If he can do it, I can do it"). In the participant's case the *example* of entering into a STEM field might merely have been the most viable option at that stage, and might not mean that she believed she could do it. One can verbalise the difference between the two types of modelling as follows: Social modelling is an attitude of "If he can do it, I can do it", while in the case of example modelling the attitude would be "Because he (or my family) does it, I might as well do it too." The two terms social modelling and example modelling will be used here.

Participant M had studied science, but left the field many years ago. She came from a family of engineers and scientists. She was more attracted to science because her older sister and cousin were both scientists. She even decided to study in a science field similar to that in which her cousin worked because she had accompanied her to work and had "liked" the experience. She completed honours and master's degrees in science. While working on her master's degree, she worked with a world-renowned scientist who was involved in research. This is a good example of **social modelling**.

Participant N shared her vicarious experiences when she said:

> *Even though my father emphasised that I shouldn't follow the same career just because it was what he did, I convinced myself that engineering sounded like a good challenge and interesting due to the various aspects included in the discipline. I realised many years later that I may have tried to please my father.*

When the researcher asked her why she had chosen engineering, she replied: "*I loved mathematics and science … I didn't want to work with people, especially not their physical problems. I realise that I tried to imitate my father too.*" This participant experienced **example modelling** and chose her career accordingly. She did not stay in the STEM-field and one could speculate that she might have stayed if she had experienced social modelling.

5.7.8.3 Supportive experiences

Supportive experiences refer to verbal and emotional encouragement as support to do something. One of the members of the STEM group, Participant B, explained the importance of verbal encouragement as follows:

> *… leaving school I wasn't sure what career I wanted to go into, but my mom's advice was just take what you have enjoyed at school and something will come up with it. So, I really enjoyed maths and physics at school and I carried on with that, ja … So for example last Friday, at the South African Institute of Physics, I got the silver medal for the, like, it is an achievement for a young researcher, who has made an impact on physics. So like, that was quite a nice award. Because my supervisor had said: 'Look you are pretty capable at winning that award' and I was a bit like 'Probably not'. So, it was like 'Wow ok'. So, it does add and boost up the encouragement.*

Clearly for this participant **verbal encouragement** was a great source of motivation to continue in her field of work.

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Participant B also mentioned how important **supportive experiences** had been by saying:

> *Well I would say one thing about the sciences, they do provide, like, awards and things. So, if you receive an award it is a lot of encouragement, it makes you think 'Ok, I am on the right track'. So being in a science type career, or a more academic one, by publishing papers, having people citing you, things like that, are a direct indication of how well you are doing. So, I think like those things add encouragement and support. I don't know if I would have to single out one highlight.*

Participant E described one of her lectures, who had encouraged her to continue with her studies, as her role model. She described her experience as follows:

> *But as you go along you do find people that motivate you. When you look at them … I did a diploma, I did not go to varsity and then I changed as I went on and then I did my degree in varsity. But when I was doing my diploma, there was this lady, one of the lecturers, I realised this lady knows her story and she was passionate in whatever she was doing. And she realised that I am more than what I think I am. I can do more and I can be more.*

The abovementioned lecturer always assisted the participant, who also said*:*

> *And if the experiment fail, I never used to be like the other students, that would go and be happy because the experiment failed, I used to go to the lecturer and ask her what might be the reasons and then I think since then, she used to be some sort of a mentor and then she motivated me.*

The lecturer has been a role model to the student and motivated her to master her field of work. This example could also be seen as a **supportive experience**. Participant H also referred to several people in her career who had contributed to her success as a mathematician. She mentioned several lecturers at university, different managers at different levels and other people in her work environment.

In the stories of the non-STEM group of participants, very little evidence of supportive experiences was found.

5.7.8.4 Emotional and physiological experiences

Emotional experiences refer to the physiological and emotional states that accompany actions. Negative emotional/physiological experiences, such as feelings of anxiety when involved in actions, feelings of self-efficacy could be reduced. This is of course not straightforward, as some people tend to become more determined to succeed when they have to deal with negative experiences.

Participant E told her story about her family that was illiterate and how she became interested in science. Her "love" for science and how it made her feel was her driving force to become a scientist. She explained:

> *… as I went on in high school I realised that no, in Chemistry I am good, I understand it and I enjoy it. For in fact, chemistry is everything, it is part of your life. You mix something else and the end product it's something else. And even yourself as a human being, you are chemistry, and I was like, this is the way to go. It was out of passion.*

She continued to explain her reaction to chemistry: *"When I was in the chemistry I was like 'Wow'*. She clearly had an **emotional experience** of satisfaction and enjoyment as a source of self-efficacy. This is an important example of an emotional experience that has the ability to increase self-efficacy. As seen above, STEM women enjoyed their work, which means that the pleasure they derived from working in STEM increased their feelings of self-efficacy.

When Participant E shared her career story, she mentioned the following:

> *Wherever I go I usually take the positives that I know would make me better. Whatever company, because I worked in different companies, Pharmaceutical, Water Industry, Sugar Industry, I don't look at the negatives. I only look at the things that would build me. I used to focus on that (positive experiences).*

She counts on positive experiences to assist her in her career performance. Participant F, an engineer, revealed the importance of being satisfied with a job well done. She said: "*I enjoy the technical side of things, I enjoy figuring out how to approach a problem."* She continued by saying: *"What really gives me satisfaction if I can give a report to a client and it looks professional and I can stand by it. That gives me satisfaction."*

This participant's experience provides us with a further qualification of an emotional experience and enjoyment of work. The enjoyment is derived not only from positive experiences, but also from the ability to solve problems and to be intellectually stimulated and challenged.

In the non-STEM group the qualitative data did not show evidence of emotional experiences as a source of career self-efficacy. In general, the researcher considered the self-efficacy of participants along with components of willingness to perform tasks, a sense of accomplishment and achieving goals.

5.7.9 Theme 9: Education barriers

Not many participants experienced education barriers in their school careers. This could be the result of the relentless efforts of, and the dynamic programmes of the Department of Science and Technology and the Minister of Science and Technology, Ms Naledi Pandor. Ms Pandor is actively engage in encouraging more young women to enter careers in science. The type of initiatives undertaken can be illustrated by the occasion on which fifteen young girls from Mothotlung High School in the North West joined staff at the Department of Science and Technology to be familiarised with what science and technology entail. Another initiative is the GirENg that aims to inform and encourage young girls to enter into the fascinating world of engineering.

Participant A shared her experience of being nominated as the best Science student in matric. At the awards ceremony, she received a poetry book because the teacher said: "*Ek het nie gedink 'n meisie sal 'n boek oor wetenskap wil hê nie" [I didn't think that a girl would want a book about science]*. All the other students received books related to their best subjects!

Participant L mentioned that she never received a proper science education. She said::

> *You know you basically … you were never … uhm exposed to … science so much. You … sit there and they … have the view of what the woman should be and the woman should be like you said in a softer job. So I would say definitely in school you didn't get a lot of support, to go into a science direction.*

She also mentioned that the teacher tried to convince her to choose teaching as a career.

Other participants also experienced negative situations at the tertiary level. Participant K mentioned how difficult it was being the only female in a class of engineers. She found it even more difficult when they were going on field trips and no provision was made for female toilets. She said: "*As a student, when we had to do practical, we had to go to the veld. I was the only woman. The only woman amongst men … Wow, this is really a guy's environment.*" Participant G said that when she entered her first class in engineering at university her first

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thought was: "*What am I doing here? A lot of males!*" However, she realised that she could not change her career just because most of the other engineering students were male.

Participant I experienced education barriers while she was studying at university. She was unable to obtain a bursary or loan to continue her studies in science and was convinced that the reason for this was that she was a woman. Several participants mentioned that there were only a few females in their classes and that they had to work extra hard to be recognised.

5.7.10 Theme 10: Personal barriers

Participant A mentioned that more female role models are needed in the field of engineering. She said:

> *And that is one of the reasons I hang around; I present an example of a decent human being, being in engineering, being a female, being truly female, being competent, so that they see that and don't find it foreign.*

She was referring to seeing successful women in the STEM workplace.

Participant J mentioned that the office hours should be more flexible to make it easier for women to remain in STEM careers. Participant I mentioned that it was difficult for women to obtain bursaries to study science.

5.7.11 Theme 11: Motivation to embark on STEM studies/a career in STEM

Participant A told her story of how she became involved in science:

> *Maths came by itself, it was not … I enjoyed science. I got the prize for the best Science pupil at our school. So it was really something I could do. So in Standard 9 what I did, I simply paged through, my father brought me a bunch of … sorry … a bunch of booklets describing different courses. So I could just page through and decide ... so, I looked at the engineering that had the most maths in so then I took electronic engineering. I really enjoyed it. I really-really enjoyed the studies, it was not … The moment I started studying it was as if the work itself kept me there. I was really interested in that, I enjoyed it.*

Participant B chose science for the following reasons:

> *So I really enjoyed maths and physics at school and I carried on with that, ja. So apart from enjoying it, I guess if you have an aptitude for a subject you enjoy it more. So that is why I enjoyed those subjects. Then I also I thought there is less competition in those fields for there is not a lot of people entering into them.*

Participants C, L H, and O also mentioned that they enjoyed maths and science and therefore chose careers in that field. Participant K chose her particular field because she loved chemistry, and Participant M mentioned that she had chosen a STEM field as she was not interested in working with people.

Participant D gave the following explanation for choosing science:

> *Okay, so when I was in high school, I wanted to do, I think I was in standard 9 or 10, I decided I was going to do astronomy, and it was because of a movie that I saw, and I thought "Wow, interesting job." So I found out about the South African Astronomical Observatory at Cape Town, Cape Town Observatory, and I wrote to them and I told them that I wanted to do astronomy.*

She was so committed to her dream that she was prepared to first study for another degree that was a prerequisite for studies in her field of interest.

Participant F wanted to be an engineer because:

> *Uhmm, I landed in engineering because I realised that there is a water supply problem in South Africa and especially in the rural communities. I really wanted to help. And engineering would have been the best way to do that. In rural communities, people are far away from water resources. They don't have access to clean water and clean water is a basic, basic thing. If you have clean water it changes things. The health of, you have healthy children and healthy families."*

She continued by saying:

> *Also from my mother's family, her brothers were engineers and so my grandfather. So, I come from a family of engineers – if I can say that. I definitely think because my family is in engineering it made a difference.*

Participant J chose science because "*I grew up in a family where science was*", Participant I had followed in her brother's footsteps, and Participant N had followed in her father's footsteps.

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Participant G chose engineering because she thought:

> *What can I do? What can I do to stay in a, very interesting, machine world? I heard about an engineer and I said, oh engineer, perfect. Then I was like oh mechanical engineer. It's somebody who's interested in how does the thing work; machines and how to solve the problem on the machine and technology.*

5.7.12 Theme 12: Leaving STEM

The researcher interviewed seven participants who had studied in STEM fields. Five of the seven later worked in STEM, but two never worked in the field. One of the two participants who had studied in the STEM field but did not pursue a STEM career said that as a woman she never received any support:

> *I was a woman. But obviously, it was a disadvantage because then, your career development and your career advancement, was a bit stunted. The other participant that did not work in the field, chose to go into a human resource career because she "wanted to work with people.*

Participant J, who had worked in STEM for 15 years, was of the opinion that the STEM work environment is not family friendly. She said: "*I always think that uhm … to me a family is, my family is very important and I wouldn't … encourage my daughter to study … in science because it's not, very, practical to have, uh, to combine family and science*."

Participants M, N and O all left the STEM field because of marriage, motherhood and family commitments. Participant M stated: "Since forever I have wanted to raise my own children." Participant O said that she had to sacrifice her career for her husband and children: "*Ongelukkig het ek dit prysgegee vir my man se loopbaan en my kinders" [Unfortunately I gave it up for the sake of my husband's career and my children*].

Participant K explained that she had left the field because she needed something "*more*." She wanted to be able to interpret financial reports and understand financial management.

5.8 Conclusion

Women who persevered in the STEM field clearly showed high levels of self-efficacy. They also displayed agency and a great deal of resilience. Their career decision making was clear and they decided to focus on their careers despite obstacles. They were willing to sacrifice time and comfort and were willing to work extraordinarily hard. They did not seek the approval of others and exhibited confidence in their abilities. They also planned their family lives and managed their time well so that they could balance work and family life. In contrast, the group that had left STEM almost invariably indicated that they left the field because of family commitments, although some had changed their careers to be able to cope with the demands of both work and their families.

Although some of the women had not shown much agency or resilience when they were in STEM careers, others did show high levels of self-efficacy and agency in their current or “new” careers. They generally found it difficult to find solutions for the obstacles they encountered.

Lastly, it can be said that the STEM women revealed substantial mastery and had vicarious modelling experiences, as well as supportive and emotional experiences, which enhanced their levels of self-efficacy. In contrast, the non-STEM group almost never mentioned having had mastery experiences and there not a single participant in this group mentioned any vicarious and emotional experiences. One can therefore conclude that a combination of source of self-efficacy experiences is required to enhance commitment to remain in a STEM career. Mastery and vicarious experiences are clearly very important. However, the most important requirement was the emotional experience of enjoying work, feeling at home in a career and finding fulfilment in the challenges encountered by women in STEM careers. Most of the women who had left the STEM field had in fact had had vicarious experiences, but on their own such experiences were not enough to convince them to remain in the field.

CHAPTER 6

RESULTS: QUANTITATIVE DATA

6.1 Introduction

This chapter reports on the quantitative data obtained from the online survey. A questionnaire was compiled to collect quantitative data. The sample was divided into two groups: a group of women who are actively employed in STEM careers and a second group who had studied in the field, but never entered STEM-related careers, or entered STEM careers but changed their careers after relatively short periods. The group membership was discussed in detail in Chapter 4.

The sample consisted of women who had been requested by their companies to complete the survey, or had been referred to the researcher by other participants. In addition, the 15 women who participated in the qualitative study also completed the questionnaire. The sample characteristics are provided in Chapter 4.

The collection of data by means of the online survey tool Qualtrix was also discussed in Chapter 4. A link to Qualtrix was sent to participating women, who completed the questionnaire online. Respondents did not have to complete their questionnaires in a single session, but could interrupt the process and continue later when it was convenient for them. Anonymity and confidentiality were guaranteed and they were also given the choice to terminate the completion at any stage. Unfortunately, this option resulted in the submission of a number of incomplete questionnaires.

The survey consisted of different sections, namely a biographical section, which included questions on the respondents' characteristics; three self-efficacy scales (the New General Self-efficacy Scale, the Occupational Self-efficacy Scale and the General Self-efficacy Scale); and the Exploratory Questionnaire (EQ), which contained various questions about motivation and barriers. Data was converted to an SPSS format from Excel spreadsheets and a number of analyses were done.

The main aim of the analyses was to compare the STEM-status groups on variables to determine whether it was possible to identify key issues that differentiated the groups. The main strategy was therefore to determine the variables that distinguished one group from the other. Since there were two groups (thus constituting a binary variable) and a number of continuous variables (scale scores and themes on the Exploratory Questionnaire), one might be able use the continuous or independent variables to construct a model that would make it possible to predict the dependent or binary variable. Since it was binary, a logistic regression was most appropriate in combination with the continuous independent variables.

In order to be able to construct this logistic regression model, a number of precursory steps needed to be followed. By exploring the data descriptively, looking for significant differences and reducing the data provided by the responses to the Exploratory Questionnaire (which consisted of 94 items), variables could be identified for inclusion in the logistic regression model.

The statistical techniques employed to reach the final goal included the following:

a. Descriptive statistics
b. Inferential statistics
c. Data reduction
d. Modelling

A theoretical discussion of the statistical techniques and method was provided in Chapter 4. In paragraph 6.2 below, the application of each technique will be noted in the steps to be followed in this chapter. In this chapter, the data analysis will be discussed along with the results of the biographical information; a discussion of the self-efficacy scales; an investigation of the EQ; a presentation of its data in a form that can be easily interpreted; and finally, a reduction of the 94 items in the EQ to a few factors that could be used in the logistic regression. Two inferential steps were included, namely a comparison of the group scores for the self-efficacy scales and the factor scores for the data- reduction phase.

6.2 Data analysis

The data analysis involved the following processes and steps and will be discussed below.

a. Description of biographical information

The results are first described in terms of the total sample constitution which includes the usual biographical descriptors such as language, age and so on. The basic sample characteristics were provided in Chapter 4 but additional biographical information in terms of STEM-status will be described, additional cross tabulations were done to explore and specific issues were clarified.

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b. Descriptive statistics of the self-efficacy scales

The results of the three self-efficacy tests which were completed by the sample were provided. These were described in terms of their psychometric properties and statistical characteristics. The first inferential analysis is applied here, with an examination of the difference between the STEM status groups for self-efficacy scales.

c. Descriptive statistics of the Exploratory Questionnaire (EQ)

The Exploratory Questionnaire consisted of 94 items about STEM barriers, motivation and STEM matters in the educational and work environments. The questionnaire, as can be seen in paragraph 6.5, were divided in to sections and these sections are statistically described as well as visually represented to enable easy interpretation.

d. Data reduction: exploratory factor analysis of the EQ

Understandably the large number of items makes it difficult to make a systematic interpretation of the differences between the STEM-status groups. An exploratory principal component analysis (PCA) – generally known as an exploratory factor analysis – was done to identify groups of items that could be meaningfully explored. A factor analysis is a data-reduction technique applied to identify a smaller number of latent variables from a large pool of items. As is evident, the number of items and sample size ratio were almost equal, which made a PCA on all 94 items nonsensical and impractical. However, arguing from the perspective of grouping variables based on inter-item correlations, the restrictions for a PCA in this instance were relaxed and the overall PCA was used as a first heuristic to identify items that showed high correlation. These packets of correlated items were used for PCAs on a smaller number of items.

e. Inferential statistics: differences between STEM-status groups for EQ factors

Group differences between STEM-status groups were determined for both the self-efficacy scales in paragraph b above and the factors identified in the PCA for the contextual items. Given the difference in size between the groups and the non-random nature of the data collection, both analyses were supported by a bootstrapping exercise to confirm the independent t-test results. The reason for the comparison between the groups was to determine whether any variables might distinguish between women in STEM careers and those that had left the STEM field.

f. Modelling: logistic regression

Finally, the ability of the factors or constructs identified from the contextual items were utilised in a binary logistic regression to determine whether any accurate classification could be made based on these factors combined with the self-efficacy scales.

It must be stated from the beginning that the methods used were dependent on a relatively normal distribution of variables. However, given the small sample and non-random selection, the techniques used and the results obtained will be discussed against the statistical requirements for these methods and the nature of the data. One cannot make improper inferences from data that is restricted in some respects, and issues such as normality of distributions, size and various indicators – such as the appropriateness of doing PCA on this sample – will be highlighted as the chapter proceeds.

The first description of results in the next section relates to the biographical variables.

6.3 Biographical results

Univariate descriptions of the sample characteristics were provided in Chapter 4. However, there were additional variables that might have clarified the sample constitution, such as when the two STEM groups were compared with respect to descriptors such as language and age. These detailed descriptions proved the extent to which the groups were comparable. In this section a number of biographical variables are cross-tabulated.

6.3.1 STEM career status and cross-tabulations

Table 25 shows the cross-tabulation between home language and STEM status. STEM status indicates whether the participant is currently in a STEM career or not. The non-STEM group is similar the STEM group, except for the inclusion of two African languages, while the category 'Other' falls in the STEM group. The STEM and non-STEM groups include 22% and 50% Afrikaans-speaking respondents respectively.

Table 25 STEM career status by language

Language	STEM Status[a]		Total
	STEM	Non-STEM	
English	61 84.7% 56.5%	11 15.3% 10.2%	72 100.0% 66.7%
IsiXhosa	3 75.0% 2.8%	1 25.0% 0.9%	4 100.0% 3.7%
IsiZulu	1 100.0% 0.9%	0 0.0% 0.0%	1 100.0% 0.9%

Language	STEM Status[a]		Total
	STEM	Non-STEM	
Sepedi	2 100.0% 1.9%	0 0.0% 0.0%	2 100.0% 1.9%
Sesotho	2 66.7% 1.9%	1 33.3% 0.9%	3 100.0% 2.8%
Afrikaans	14 70.0% 13.0%	6 30.0% 5.6%	20 100.0% 18.5%
Setswana	2 66.7% 1.9%	1 33.3% 0.9%	3 100.0% 2.8%
Other (Specify)	3 100.0% 2.8%	0 0.0% 0.0%	3 100.0% 2.8%
	88 81.5%	20 18.5% 18.5%	108 100.0% 100.0%

a. Count
Row percentage
Column percentage

Table 26 indicates larger numbers of married than single participants in both the STEM and non-STEM groups although the proportion between single and married is approximately 45% for STEM women and 29% non-STEM women. As can be seen in Table 26 below, both groups included more married than single women.

Table 26 STEM career status by marital status

	STEM Status[a]		Total
	STEM	Non-STEM	
Married	55 79.7% 50.9%	14 20.3% 13.0%	69 100.0% 63.9%
Single	25 86.2% 23.1%	4 13.8% 3.7%	29 100.0% 26.9%
Divorced	2 66.7% 1.9%	1 33.3% 0.9%	3 100.0% 2.8%
Widow	2 100.0% 1.9%	0 0.0% 0.0%	2 100.0% 1.9%
Married (traditional)	4 80.0% 3.7%	1 20.0% 0.9%	5 100.0% 4.6%
	88 81.5% 81.5%	20 18.5% 18.5%	108 100.0% 100.0%

a. Count
Row percentage
Column percentage

Table 27 shows that the STEM category included one person with a Grade 12 certificate, who probably was an undergraduate STEM student. In the non-STEM group, there were four participants with diplomas, but no one in the STEM group had a diploma. The one person with a PhD was in the non-STEM group. Most of the non-STEM participants had honours degrees and the majority of STEM participants had master's degrees.

Table 27 STEM career status by highest qualification

	STEM Status[a]		Total
	STEM	**Non-STEM**	
Grade 12	1 100.0% 0.9%	0 0.0% 0.0%	1 100.0% 0.9%
Technikon Diploma	0 0.0% 0.0%	4 100.0% 3.7%	4 100.0% 3.7%
Bachelor's degree	8 66.7% 7.4%	4 33.3% 3.7%	12 100.0% 11.1%
Honours degree	29 80.6% 26.9%	7 19.4% 6.5%	36 100.0% 33.3%
Master's degree	50 92.6% 46.3%	4 7.4% 3.7%	54 100.0% 50.0%
D or PhD degree	0 0.0% 0.0%	1 100.0% 0.9%	1 100.0% 0.9%
	88 81.5% 81.5%	20 18.5% 18.5%	108 100.0% 100.0%
a. Count Row percentage Column percentage			

Table 28 shows that the majority of the respondents in both STEM groups were employed in the educational sector.

Table 28 STEM career status by current company

	STEM Status[a]		Total
	STEM	**Non-STEM**	
Non-governmental organisation	1 50.0% 1.0%	1 50.0% 1.0%	2 100.0% 2.0%
Engineering consultants / firms	2 66.7% 2.0%	1 33.3% 1.0%	3 100.0% 3.0%
Education	62 83.8% 61.4%	12 16.2% 11.9%	74 100.0% 73.3%
Own business	2 50.0% 2.0%	2 50.0% 2.0%	4 100.0% 4.0%

	STEM Status[a]		Total
	STEM	Non-STEM	
Research institute	11 100.0% 10.9%	0 0.0% 0.0%	11 100.0% 10.9%
Government department	4 66.7% 4.0%	2 33.3% 2.0%	6 100.0% 5.9%
Unemployed	0 0.0% 0.0%	1 100.0% 1.0%	1 100.0% 1.0%
	82 81.2% 81.2%	19 18.8% 18.8%	101 100.0% 100.0%

a. Count
Row percentage
Column percentage

Table 29 indicates that the majority of STEM women were in the academic group (n = 53). Two non-STEM participants indicated their positions as trainer and HR. It is interesting to note that two participants in the non-STEM group characterised their position as scientist (which does not make sense). The other positions indicated by both groups were consistent with their status. The STEM group included quite a high number of students (11). A cross-tabulation between current position and highest qualification showed that 9 of the 11 students had honours degrees, which meant that they were at the time involved in master's studies.

Table 29 STEM career status by current position

	STEM Status[a]		Total
	STEM	Non-STEM	
Management	14 73.7% 13.3%	5 26.3% 4.8%	19 100.0% 18.1%
Consultant	1 33.3% 1.0%	2 66.7% 1.9%	3 100.0% 2.9%
Trainer	0 0.0% 0.0%	1 100.0% 1.0%	1 100.0% 1.0%
Scientist	7 77.8% 6.7%	2 22.2% 1.9%	9 100.0% 8.6%
Student	11 78.6% 10.5%	3 21.4% 2.9%	14 100.0% 13.3%
Academic	53 93.0% 50.5%	4 7.0% 3.8%	57 100.0% 54.3%
HR	0 0.0% 0.0%	2 100.0% 1.9%	2 100.0% 1.9%
	86 81.9% 81.9%	19 18.1% 18.1%	105 100.0% 100.0%

a. Count
Row percentage
Column percentage

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Table 30 shows that there were more younger participants (25 to 29 years) in the STEM group than in the non-STEM group. While on average the non-STEM respondents were older, the STEM group included seven women between the ages of 60 to 64 years and therefore had both more older and more younger participants.

Table 30 STEM career status by age categories

AGE (Years)	STEM Status[a]		Total
	STEM	Non-STEM	
20-24	1 33.3% 0.9%	2 66.7% 1.9%	3 100.0% 2.8%
25-29	11 91.7% 10.2%	1 8.3% 0.9%	12 100.0% 11.1%
30-34	25 86.2% 23.1%	4 13.8% 3.7%	29 100.0% 26.9%
35-39	19 95.0% 17.6%	1 5.0% 0.9%	20 100.0% 18.5%
40-44	5 62.5% 4.6%	3 37.5% 2.8%	8 100.0% 7.4%
45-49	9 69.2% 8.3%	4 30.8% 3.7%	13 100.0% 12.0%
50-54	9 90.0% 8.3%	1 10.0% 0.9%	10 100.0% 9.3%
55-59	2 40.0% 1.9%	3 60.0% 2.8%	5 100.0% 4.6%
60-64	7 100.0% 6.5%	0 0.0% 0.0%	7 100.0% 6.5%
65-69	0 0.0% 0.0%	1 100.0% 0.9%	1 100.0% 0.9%
	88 81.5% 81.5%	20 18.5% 18.5%	108 100.0% 100.0%

a. Count
Row percentage
Column percentage

Table 31 shows that the majority of STEM participants (46 or 44% of the total sample) had been in their current careers for periods ranging from 0 to 3 years. In the non-STEM group, 12 women had been in their current positions for 0 to 3 years. Of the women in the STEM group, 38 (37%) seemed to be relatively experienced in their current positions (four or more years).

Table 31 STEM career status by years in current position

AGE (Years)	STEM Status[a]		Total
	STEM	Non-STEM	
0-3	46 79.3% 44.2%	12 20.7% 11.5%	58 100.0% 55.8%
4-6	19 90.5% 18.3%	2 9.5% 1.9%	21 100.0% 20.2%
7-9	10 90.9% 9.6%	1 9.1% 1.0%	11 100.0% 10.6%
10-12	6 85.7% 5.8%	1 14.3% 1.0%	7 100.0% 6.7%
13-15	1 50.0% 1.0%	1 50.0% 1.0%	2 100.0% 1.9%
16-18	1 100.0% 1.0%	0 0.0% 0.0%	1 100.0% 1.0%
22-24	1 100.0% 1.0%	0 0.0% 0.0%	1 100.0% 1.0%
25-27	0 0.0% 0.0%	1 100.0% 1.0%	1 100.0% 1.0%
28-30	0 0.0% 0.0%	1 100.0% 1.0%	1 100.0% 1.0%
40-42	0 0.0% 0.0%	1 100.0% 1.0%	1 100.0% 1.0%
	84 80.8% 80.8%	20 19.2% 19.2%	104 100.0% 100.0%

a. Count
Row percentage
Column percentage

6.3.2 Additional exploration with cross-tabulation

In order to explore some of the issues flagged above, additional cross-tabulations were done. Current position and years in that position are summarised in Table 32. As previously mentioned, 46 of the respondents had been in their positions for 0–3 years. In the STEM group, 65 (78%) of the 82 women interviewed had been in their positions for less than six years. The majority of the STEM respondents who had been in their current positions for between nought and six years were students and academics. The rest of this group consisted of eight individuals in management and six scientists. In the non-STEM group, which consisted of 19 women, 14 (74%) had been in their positions for less than six years.

Table 32 Years in current position by current position by STEM status

STEM status			Current position							Total
			Management	Consultant	Trainer	Scientist	Student	Academic	HR	
STEM	Years in current position	0-3	5	1		5	8	27		46
		4-6	3	0		1	1	14		19
		7-9	5	0		0	0	4		9
		10-12	0	0		1	0	5		6
		13-15	0	0		0	0	1		1
		16-18	1	0		0	0	0		1
		22-24	0	0		0	0	1		1
	Total		14	1		7	9	52		83
Non-STEM	Years in current position	0-3	4	2	1	1	2	1	1	12
		4-6	0	0	0	0	1	0	1	2
		7-9	1	0	0	0	0	0	0	1
		10-12	0	0	0	0	0	1	0	1
		13-15	0	0	0	1	0	0	0	1
		25-27	0	0	0	0	0	1	0	1
		40-42	0	0	0	0	0	1	0	1
	Total		5	2	1	2	3	4	2	19
Total	Years in current position	0-3	9	3	1	6	10	28	1	58
		4-6	3	0	0	1	2	14	1	21
		7-9	6	0	0	0	0	4	0	10
		10-12	0	0	0	1	0	6	0	7
		13-15	0	0	0	1	0	1	0	2
		16-18	1	0	0	0	0	0	0	1
		22-24	0	0	0	0	0	1	0	1
		25-27	0	0	0	0	0	1	0	1
		40-42	0	0	0	0	0	1	0	1
	Total		19	3	1	9	12	56	2	102

As can be seen in Table 33, the majority of the STEM group participants in the 0–3 years slot for current position were in the 30–39 years age group. The same applies to the category 4–6 years in current position. Twenty-seven of the 46 (58%) respondents were in the 30 to 39 years age category. Nine were in the 25–29 years group, which therefore probably included those who had recently completed their studies. However, the point is that a large number of relatively experienced professionals had been in their current positions for 0–3 years, which implies some movement in respect of their jobs or positions. In contrast, the non-STEM group was distributed fairly equally over all the age groups for the category 0–3 years in current position.

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Table 34 provides a breakdown of the participants' current companies and positions. Of the 53 STEM participants employed in the academic field, 47 were working in educational settings and five in research institutes. Of the 62 in academic institutions, seven were in management, one labelled herself as a scientist, seven were students and 47 identified themselves as academic. It can be assumed that the 62 were primarily involved at academic institutions, while the six who were employed at research institutes and who identified themselves as academics had ben seconded to research institutions outside academic institutions, or were primarily working in research institutes, but within the educational setting.

With regard to the non-STEM group, it can only be assumed that they were not employed in STEM fields, even though they might have been working at research institutes and indicated that they were scientists or were involved in education.

Table 33 Years in current position by age categories by STEM-status cross-tabulation

STEM status			Age Categories[a]										Total
			20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	
STEM	Years in current position	0-3	1 1.2%	9 10.7%	15 17.9%	12 14.3%	3 3.6%	1 1.2%	2 2.4%	0 0.0%	3 3.6%		46 54.8%
		4-6	0 0.0%	1 1.2%	6 7.1%	5 6.0%	0 0.0%	5 6.0%	1 1.2%	0 0.0%	1 1.2%		19 22.6%
		7-9	0 0.0%	0 0.0%	2 2.4%	1 1.2%	0 0.0%	2 2.4%	5 6.0%	0 0.0%	0 0.0%		10 11.9%
		10-12	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 1.2%	1 1.2%	2 2.4%	2 2.4%		6 7.1%
		13-15	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 1.2%	0 0.0%	0 0.0%	0 0.0%	0 0.0%		1 1.2%
		16-18	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 1.2%	0 0.0%	0 0.0%	0 0.0%	0 0.0%		1 1.2%
		22-24	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 1.2%		1 1.2%
	Total		1 1.2%	10 11.9%	23 27.4%	18 21.4%	5 6.0%	9 10.7%	9 10.7%	2 2.4%	7 8.3%		84 100.0%
Non-STEM	Years in current position	0-3	2 10.0%	1 5.0%	3 15.0%	1 5.0%	1 5.0%	2 10.0%	1 5.0%	1 5.0%		0 0.0%	12 60.0%
		4-6	0 0.0%	0 0.0%	1 5.0%	0 0.0%	1 5.0%	0 0.0%	0 0.0%	0 0.0%		0 0.0%	2 10.0%
		7-9	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 5.0%	0 0.0%	0 0.0%	0 0.0%		0 0.0%	1 5.0%
		10-12	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 5.0%	0 0.0%	0 0.0%		0 0.0%	1 5.0%
		13-15	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 5.0%	0 0.0%	0 0.0%		0 0.0%	1 5.0%
		25-27	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 5.0%		0 0.0%	1 5.0%
		28-30	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 5.0%		0 0.0%	1 5.0%
		40-42	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%		1 5.0%	1 5.0%
	Total		2 10.0%	1 5.0%	4 20.0%	1 5.0%	3 15.0%	4 20.0%	1 5.0%	3 15.0%		1 5.0%	20 100.0%

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STEM status			Age Categories[a]										Total
			20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	
Total	Years in current position	0-3	3 2.9%	10 9.6%	18 17.3%	13 12.5%	4 3.8%	3 2.9%	3 2.9%	1 1.0%	3 2.9%	0 0.0%	58 55.8%
		4-6	0 0.0%	1 1.0%	7 6.7%	5 4.8%	1 1.0%	5 4.8%	1 1.0%	0 0.0%	1 1.0%	0 0.0%	21 20.2%
		7-9	0 0.0%	0 0.0%	2 1.9%	1 1.0%	1 1.0%	2 1.9%	5 4.8%	0 0.0%	0 0.0%	0 0.0%	11 10.6%
		10-12	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	2 1.9%	1 1.0%	2 1.9%	2 1.9%	0 0.0%	7 6.7%
		13-15	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 1.0%	1 1.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	2 1.9%
		16-18	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 1.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 1.0%
		22-24	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 1.0%	0 0.0%	1 1.0%
		25-27	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 1.0%	0 0.0%	0 0.0%	1 1.0%
		28-30	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 1.0%	0 0.0%	0 0.0%	1 1.0%
		40-42	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 1.0%	1 1.0%
	Total		3 2.9%	11 10.6%	27 26.0%	19 18.3%	8 7.7%	13 12.5%	10 9.6%	5 4.8%	7 6.7%	1 1.0%	104 100.0%

a. Number
% of total

Table 34 Current position by current company by STEM-status cross-tabulation

STEM status			Current Company[a]							Total
			Non-governmental organisation	Engineering consultants/ company	Education	Own business	Research institute	Government department	Unemployed	
Yes	Current position	Management	1 1.2%	0 0.0%	7 8.6%	0 0.0%	1 1.2%	3 3.7%		12 14.8%
		Consultant	0 0.0%	1 1.2%	0 0.0%	0 0.0%	0 0.0%	0 0.0%		1 1.2%
		Scientist	0 0.0%	1 1.2%	1 1.2%	1 1.2%	3 3.7%	1 1.2%		7 8.6%
		Student	0 0.0%	0 0.0%	7 8.6%	0 0.0%	1 1.2%	0 0.0%		8 9.9%
		Academic	0 0.0%	0 0.0%	47 58.0%	0 0.0%	6 7.4%	0 0.0%		53 65.4%
	Total		1 1.2%	2 2.5%	62 76.5%	1 1.2%	11 13.6%	4 4.9%		81 100.0%
No	Current position	Management	1 5.3%	0 0.0%	2 10.5%	1 5.3%		1 5.3%	0 0.0%	5 26.3%
		Consultant	0 0.0%	1 5.3%	1 5.3%	0 0.0%		0 0.0%	0 0.0%	2 10.5%
		Trainer	0 0.0%	0 0.0%	1 5.3%	0 0.0%		0 0.0%	0 0.0%	1 5.3%
		Scientist	0 0.0%	0 0.0%	1 5.3%	1 5.3%		0 0.0%	0 0.0%	2 10.5%
		Student	0 0.0%	0 0.0%	2 10.5%	0 0.0%		0 0.0%	1 5.3%	3 15.8%
		Academic	0 0.0%	0 0.0%	4 21.1%	0 0.0%		0 0.0%	0 0.0%	4 21.1%
		HR	0 0.0%	0 0.0%	1 5.3%	0 0.0%		1 5.3%	0 0.0%	2 10.5%
	Total		1 5.3%	1 5.3%	12 63.2%	2 10.5%		2 10.5%	1 5.3%	19 100.0%

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STEM status			Current Company[a]							Total
			Non-governmental organisation	Engineering consultants/ company	Education	Own business	Research institute	Government department	Unemployed	
Total	Current position	Management	2 2.0%	0 0.0%	9 9.0%	1 1.0%	1 1.0%	4 4.0%	0 0.0%	17 17.0%
		Consultant	0 0.0%	2 2.0%	1 1.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	3 3.0%
		Trainer	0 0.0%	0 0.0%	1 1.0%	0 0.0%	0 0.0%	0 0.0%	0 0.0%	1 1.0%
		Scientist	0 0.0%	1 1.0%	2 2.0%	2 2.0%	3 3.0%	1 1.0%	0 0.0%	9 9.0%
		Student	0 0.0%	0 0.0%	9 9.0%	0 0.0%	1 1.0%	0 0.0%	1 1.0%	11 11.0%
		Academic	0 0.0%	0 0.0%	51 51.0%	0 0.0%	6 6.0%	0 0.0%	0 0.0%	57 57.0%
		HR	0 0.0%	0 0.0%	1 1.0%	0 0.0%	0 0.0%	1 1.0%	0 0.0%	2 2.0%
	Total		2 2.0%	3 3.0%	74 74.0%	3 3.0%	11 11.0%	6 6.0%	1 1.0%	100 100.0%

a. Number
% of total

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6.4 Self-efficacy scales

Participants completed three self-efficacy scales, namely the New General Self-Efficacy Scale (NGSES), the Occupational Self-Efficacy Scale (OSES) and the General Self-Efficacy Scale (GSES). The nature and properties of the scales were discussed in Chapter 4. In this section the psychometric and statistical properties of the scales for the sample are provided.

6.4.1 Psychometric properties of self-efficacy scales

Table 35 indicates the descriptive statistics for the three self-efficacy scales. It can be seen that the means for each scale for the two STEM groups are very similar. For the Occupational Self-Efficacy Scale (OSES) for the STEM group it is 82.6 (SD = 9.36), and for the non-STEM group 82.5 (SD = 8.89). In the table the reliability of the three scales is also indicated. Both the OSES and GSES had reliability values of .90 and more. The NGSES's reliability is adequate. Both groups displayed high levels of self-efficacy. The OSES has a maximum of 100 and the mean score was significantly higher than the midpoint of 50. The same applies to the other two scales, which each has a maximum of 50 and a midpoint of 25. For both groups, scores close to 40 showed high levels of self-efficacy.

Table 35 Descriptive statistics for three Self-efficacy scales by STEM status

	STEM			**Non-STEM**			**Reliability for total sample (N = 108)**		**Group differences**		
	Mean	N	Std. Deviation	Mean	N	Std. Deviation	Cronbach Alpha	No of items	t-value	df	p
Occupational SE Scale	81.60	88	12.42	82.45	20	8.89	0.90	20	0.05	104.00	0.96
New General SE Scale	41.43	88	4.26	41.10	20	4.39	0.78	10	0.23	104.00	0.82
General SE Scale	41.17	86	5.48	41.35	20	5.19	0.91	10	-0.13	104.00	0.90

Table 36 shows the Pearson correlation between the scores for the different scales. The GSES showed a high correlation with the other two scales. The NGSES and OSES also correlated significantly (r = .50, $p \leq .01$). This implies that the GSES probably incorporates most of the variance of the OSES and NGSES. In other words, if one had to choose the instrument that best covered the constructs, the most general choice would be the GSES.

Table 36 SE scales' inter-correlation matrix (N = 108)

	Occupational SE Scale	New General SE Scale
Occupational SE Scale (OSES)		
New General SE Scale (NGSES)	.50**	
General SE Scale (GSES)	.86**	.73**
** Correlation is significant at the 0.01 level (2-tailed)		

6.4.2 Inferential statistics: differences between STEM-status groups for self-efficacy scales

Table 35 indicates that the means of the three self-efficacy scales are very close to each other and a t-test for independent samples showed no significant differences between the two STEM-status groups (in all cases between-group variance was homogenous). The assumption was that the STEM groups would differ in respect of their levels of self-efficacy, thus, H_0 was $\mu_1 = \mu_2$. The alternative hypothesis was that the non-STEM group would have lower self-efficacy than the STEM group ($\mu_1 < \mu_2$). The significance level was set at 0.05 and directional, thus $\alpha \leq 0.05$. Note that the reported significance values (*p*) in Table 35 and Table 37 are two-tailed.

Given the small sample sizes and non-random nature of the data, a bootstrap was done in order to support (or disconfirm) the results of the t-test (see Chapter 4). A bootstrap rather than a non-parametric was used because the latter is based on ranks. The sampling method was *simple*, the number of samples was 1 000, a confidence interval level was set at 95.0% and the confidence interval type was bias-corrected and accelerated (*BCa*) (see Chapter 4) (Field, 2013). Table 37 shows the results of the bootstrap. The 95% confidence interval, for instance, shows that for the OSES the differences between the means for the two groups could range from –4 to 4, which implies that it could just as well be 0. Although the very wide range already indicates that we cannot have any confidence in the observed difference, the fact that a possible value can include 0 (i.e., no difference at all) confirms the non-significance found with the t-test in Table 35 (Field, 2013). The same argument applies to the differences in means for the NGSES and the GSE.

Table 37 Bootstrap for independent sample t-test for self-efficacy scales

	Mean difference	Bootstrap				
		Bias	Standard error	Sig. (2-tailed)	BCa 95% confidence interval Lower	Upper
Occupational SE Scale (OSES)	.11	-.09	2.27		-4.34	4.46
New General SE Scale (NGSES)	.25	-.03	1.08	.84	-1.64	2.25
General SE Scale (GSES)	-.18	-.08	1.33	.90	-2.67	2.24

6.5 Exploratory Questionnaire (EQ)

The Exploratory Questionnaire (EQ) consisted of 94 items designed to explore women's experience of the STEM field. The items ranged from assessing experiences of barriers in the workplace, at school and at university, as well as personal barriers, motivational experiences and the impact of role models and family on the respondents' decision to embark on and remain in STEM careers, among others.

The EQ was discussed in Chapter 4. To facilitate the reading of Table 38, each section of rated items also indicates its rating scale. Table 38 provides the statistical information for each item in the EQ. The items were organised in sections and focused on the following areas:

a. Motivation for STEM studies
b. Factors contributing to remaining in STEM career
c. Role models motivating individuals to engage in STEM studies
d. Other influences on the decision to embark on a STEM career
e. Influences on the decision to embark on STEM studies
f. Barriers in tertiary studies
g. Barriers in work
h. Overcoming barriers
i. Overcoming difficulties
j. General questions 1
k. General questions 2
l. Societal expectations
m. Progress in women's careers

6.5.1 Results for the Exploratory Questionnaire (EQ)

Each question and its leading question are provided in the table, along with the number of respondents who had answered the question and the usual statistical properties of the items. The response scale ranged from 1 to 5 and the anchors are indicated with each question in Table 38. The minimum score for each answer is 1 and the maximum 5. Given the large number of items and the small sample sizes of each group, it would not be valid to do a t-test to compare differences between the STEM and non-STEM groups for each question. A basic principle is that a search for statistical difference sometimes yields significant differences purely by chance, especially if the number of t-tests increases (Shadish et al., 2001). Another reason for avoiding this practice is the effect of the Bonferroni adjustment required for inflated error rates (Field, 2013, pp. 68-69). The eventual exceedance probability will be very small and impractical to implement.

In paragraph 6.5.2 below, the information in Table 38 is visually presented as line graphs of means for each section of questions. Each section is discussed separately.

Table 38 Results for the Exploratory Questionnaire (EQ)

Number	Question	STEM			Non-STEM			Total		
		Mean	N	Standard deviation	Mean	N	Standard deviation	Mean	N	Standard deviation
	1. To what extent did the following motivate you to embark on studies to follow a career path in Science, Engineering and Technology (STEM)? This applies whether or not you are currently in a STEM career. Never (1) To a small extent (2) To some extent (3) To a great extent (4) Always (5)									
Q4.1_1	Father (1)	3.42	85	1.409	3.16	19	1.608	3.38	104	1.443
Q4.1_2	Mother (2)	3.34	86	1.334	2.89	19	1.243	3.26	105	1.323
Q4.1_3	Teacher (3)	3.32	84	1.253	3.11	19	1.243	3.28	103	1.248
Q4.1_4	My own fascination with science (4)	4.27	85	0.918	4.05	19	0.78	4.23	104	0.895
Q4.1_5	Attending science fairs/exhibitions (5)	2.65	86	1.387	2	19	1.202	2.53	105	1.373
Q4.1_6	Attending science programmes at institutions (6)	2.67	85	1.499	2.32	19	1.204	2.61	104	1.451
Q4.1_7	A female role model (7)	2.44	84	1.467	2.06	18	1.474	2.37	102	1.469
Q4.1_8	A male role model (8)	2.46	83	1.373	2.42	19	1.61	2.45	102	1.412
	2. To what extent did the following factors contribute towards you remaining a professional in this field? Never (1) Rarely (2) Sometimes (3) Often (4) All of the Time (5)									
Q4.2_1	I enjoy my work. (1)	4.28	85	0.629						
Q4.2_2	I receive acknowledgment for my expertise. (2)	3.62	85	0.801						
Q4.2_3	I am regarded as an expert. (3)	3.35	84	0.871						
Q4.2_4	My work has a beneficial impact on others. (4)	3.93	84	0.875						
Q4.2_5	I can publish my work. (5)	3.56	84	1.302						
Q4.2_6	I enjoy working with colleagues. (6)	3.89	84	0.865						
Q4.2_7	I enjoy developing my skills. (7)	4.46	85	0.646						
Q4.2_8	I enjoy doing research. (8)	4.18	85	0.941						
Q4.2_9	I enjoy doing practical things. (9)	4.2	85	0.884						
Q4.2_10	I set high goals for myself. (10)	4.33	84	0.717						
Q4.2_11	My work has an international impact. (11)	3.78	85	1.084						
Q4.2_12	My work has a great effect on the world. (12)	3.35	84	1.058						

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Number	Question	STEM			Non-STEM			Total		
		Mean	N	Standard deviation	Mean	N	Standard deviation	Mean	N	Standard deviation
Q4.2_13	To what extent did you experience difficulties as a woman on your way to success? (13)	3.14	85	1.048						
	3. To what extent has the following person/people been a role model/ role models WHO ENCOURAGED YOU to become interested in STEM (whether you are in a STEM career or not)? Never (1) Rarely (2) Sometimes (3) Often (4) All of the Time (5)									
Q4.4_1	Parents (1)	3.76	85	1.25	3.37	19	1.535	3.69	104	1.308
Q4.4_2	Female achievers (2)	2.98	85	1.363	2.68	19	1.293	2.92	104	1.349
Q4.4_3	Male achievers (3)	2.79	84	1.262	2.47	19	1.307	2.73	103	1.27
Q4.4_4	Teacher(s) at school (4)	3.19	84	1.146	3.16	19	1.167	3.18	103	1.144
Q4.4_5	Lecturer at varsity (5)	3.42	85	1.209	3.22	18	1.478	3.39	103	1.254
Q4.4_6	Female colleagues (6)	3.06	84	1.216	2.68	19	1.25	2.99	103	1.225
Q4.4_7	Male colleagues (7)	3	82	1.144	2.63	19	1.212	2.93	101	1.16
	4. To what extent did the following influence your involvement in STEM (whether you are in a STEM career or not)? Never (1) Rarely (2) Sometimes (3) Often (4) All of the Time (5)									
Q4.5_1	Did primary school influence your perceptions negatively about science? (1)	1.54	85	0.92	1.42	19	0.769	1.52	104	0.892
Q4.5_2	Did high school influence your perceptions negatively about science? (2)	1.72	85	1.087	1.74	19	0.991	1.72	104	1.065
Q4.5_3	Were some teachers prejudiced against girls doing maths and science? (3)	1.79	84	1.12	1.63	19	1.065	1.76	103	1.107
Q4.5_4	Did you ever doubt your ability to do maths? (4)	2.23	84	1.226	2.26	19	1.447	2.23	103	1.262
Q4.5_5	Did you ever doubt your ability to do science? (5)	2.13	85	1.033	1.89	19	1.329	2.09	104	1.089
Q4.5_6	Did you ever feel you were not suited for a career in STEM? (6)	2.13	84	1.117	1.95	19	1.026	2.1	103	1.098
Q4.5_7	To what extent are women's perceptions of STEM influenced by their teachers in a positive way? (7)	3.61	82	0.899	3.61	18	0.916	3.61	100	0.898
Q4.5_8	To what extent are women's perceptions of STEM negatively influenced by their teachers? (8)	3.18	83	1.061	2.58	19	1.121	3.07	102	1.092
	5. To what extent did the following motivate you to pursue / choose your field of study (whether you are in a STEM career or not)? Never (1) Rarely (2) Sometimes (3) Often (4) All of the Time (5)									

Number	Question	STEM			Non-STEM			Total		
		Mean	N	Standard deviation	Mean	N	Standard deviation	Mean	N	Standard deviation
Q4.6_1	Personal interest in science (1)	4.51	85	0.766	4.16	19	0.898	4.44	104	0.798
Q4.6_2	Availability of bursaries (2)	2.99	83	1.348	2.84	19	1.573	2.96	102	1.385
Q4.6_3	Parents' interest in science (3)	3	85	1.354	2.95	19	1.268	2.99	104	1.333
Q4.6_4	Teachers' motivation (4)	3.16	85	1.132	2.79	19	1.316	3.1	104	1.17
	6. To what extent did you encounter the following difficulties as a woman in your studies at your tertiary institution? (These could be psychological, institutional, cultural or technological) Never (1) Rarely (2) Sometimes (3) Often (4) All of the Time (5)									
Q4.7_1	I doubted my ability to pass a STEM course. (1)	2.2	85	1.021	2	19	1.054	2.16	104	1.025
Q4.7_2	I faced negativity from male students in class. (2)	1.98	85	1.123	1.74	19	1.046	1.93	104	1.108
Q4.7_3	I faced negativity from female students in class. (3)	1.72	85	0.895	1.37	19	0.496	1.65	104	0.845
Q4.7_4	Lecturers were negative towards women. (4)	1.68	85	0.954	2.05	19	1.026	1.75	104	0.973
Q4.7_5	My community regarded STEM careers as not for women. (5)	1.77	84	1.022	1.74	19	0.933	1.77	103	1.002
Q4.7_6	I didn't like technology. (6)	1.51	85	0.781	1.47	19	0.772	1.5	104	0.776
Q4.7_8	Curriculum was gender insensitive. (8)	1.56	85	0.823	1.63	19	1.065	1.58	104	0.867
Q4.7_9	The whole tertiary educational system was male dominated. (9)	2.73	85	1.219	2.37	19	1.165	2.66	104	1.212
Q4.7_10	To what extent have you, during your training, ever been marginalised because you are a woman? (10)	2.17	84	0.929	2.26	19	1.24	2.18	103	0.988
	7. Which of the following barriers do women face in STEM careers today? Never (1) Rarely (2) Sometimes (3) Often (4) All of the Time (5)									
	To what extent did the following issues influence you to leave your intended STEM career? Never (1) Rarely (2) Sometimes (3) Often (4) All of the Time (5)									
Q5.1_1	Recruitment practices discriminate against women (1)	2.59	82	0.888	2.61	18	1.42	2.59	100	0.996
Q5.1_2	Hiring practices (2)	2.69	81	0.846	2.65	17	1.455	2.68	98	0.97
Q5.1_3	Women tend to have a lack of self-confidence. (3)	3.27	83	0.842	2.44	18	1.338	3.12	101	0.993
Q5.1_4	There is a lack of information on STEM careers. (4)	3.12	81	0.9	2.78	18	1.437	3.06	99	1.018
Q5.1_5	Lack of career opportunities for women (5)	2.6	81	0.89	2.94	18	1.349	2.67	99	0.99
Q5.1_6	Lack of role models (6)	3.13	82	0.926	2.67	18	1.283	3.05	100	1.009

Number	Question	STEM			Non-STEM			Total		
		Mean	N	Standard deviation	Mean	N	Standard deviation	Mean	N	Standard deviation
Q5.1_7	A gender pay gap (7)	3.19	80	1.148	2.61	18	1.539	3.08	98	1.241
Q5.1_8	Women are not as interested in science as men are. (8)	2.46	83	0.979	2.06	18	0.873	2.39	101	0.969
Q5.1_9	The workplace is male dominated. (9)	3.59	82	1.018	3.11	18	1.231	3.5	100	1.068
Q5.1_10	The workplace discriminates against women.. (10)	2.74	82	0.914	2.89	18	1.183	2.77	100	0.962
Q5.1_11	Women are not included in management. (11)	2.94	82	1.035	2.83	18	1.249	2.92	100	1.07
Q5.1_12	Women's career opportunities are limited. (12)	2.63	82	1	2.94	18	1.211	2.69	100	1.042
Q5.1_13	Women are not promoted. (13)	2.68	81	0.998	2.89	18	1.183	2.72	99	1.031
Q5.1_14	STEM work is physically harder for women. (14)	2.09	81	0.897	1.83	18	0.786	2.04	99	0.88
Q5.1_16	Other women discriminate against me. (17)	2.2	83	0.985	2.71	17	1.213	2.29	100	1.038
Q5.1_18	Male discrimination just motivates me to work harder. (18)	3.38	82	1.162	3.53	17	1.231	3.4	99	1.169
Q5.1_19	Racism motivates me to prove myself. (19)	3.05	82	1.422	3.22	18	1.665	3.08	100	1.461
Q5.1_20	Racism is a bigger problem than gender discrimination. (20)	3.18	83	1.095	3.41	17	1.502	3.22	100	1.168
Q5.1_21	Balancing children with a career is difficult. (21)	4.17	81	0.863	4.11	18	1.183	4.16	99	0.923
Q5.1_22	Combining married life with a career is difficult. (22)	3.41	80	1.177	3.06	18	1.305	3.35	98	1.202
Q5.1_23	Professional women spend too much time at work. (23)	3.43	82	1.007	3.28	18	1.018	3.4	100	1.005
Q5.1_24	I do not have time for a family. (24)	2.85	82	1.124	3.06	18	1.305	2.89	100	1.154
Q5.1_25	Balancing career and personal life is difficult. (25)	3.6	83	0.936	3.44	18	0.856	3.57	101	0.92
Q5.1_26	Men at work make jokes about professional women. (26)	2.45	83	1.222	2.5	18	1.15	2.46	101	1.204
Q5.1_27	Racism at work is a problem. (27)	2.58	80	1.156	2.72	18	1.227	2.6	98	1.164
Q5.1_28	It is difficult to resume a career after taking maternity leave. (28)	3.37	81	0.858	3	18	1.414	3.3	99	0.984
Q5.1_29	Work hours are inflexible. (29)	2.84	81	1.089	2.72	18	1.406	2.82	99	1.146

Number	Question	STEM			Non-STEM			Total		
		Mean	N	Standard deviation	Mean	N	Standard deviation	Mean	N	Standard deviation
Q5.1_30	Work does not cater for women with children. (30)	3.41	82	1.111	3.33	18	1.283	3.4	100	1.137
Q5.1_31	I would prefer working from home. (31)	3.29	82	1.036	3.56	18	1.149	3.34	100	1.056
Q5.1_32	Colleagues discriminate against women. (32)	2.15	82	1.032	2	18	1.138	2.12	100	1.047
Q5.1_33	Management discriminates against women. (33)	2.17	82	1.04	2.56	18	1.042	2.24	100	1.046
Q5.1_34	It is difficult to be a female manager. (34)	2.84	81	1.123	2.5	18	1.098	2.78	99	1.121
Q5.1_35	It is difficult to adapt to a male-dominated environment. (35)	2.74	82	0.953	2.22	18	1.06	2.65	100	0.989
Q5.1_36	Science is seen as a male career field. (36)	3.09	82	1.056	2.94	18	1.305	3.06	100	1.099
Q5.1_37	Women should not work in a technological environment. (37)	1.33	79	0.655	1.56	18	1.042	1.37	97	0.74
	8. To what extent do you think these barriers can be overcome? Never (1) Rarely (2) Sometimes (3) Often (4) All of the Time (5)									
Q6.2_1	These barriers can be overcome. (1)	3.9	81	0.752	3.78	18	0.808	3.88	99	0.76
Q6.2_2	It depends on how hard women work. (2)	3.56	81	0.949	2.83	18	1.15	3.42	99	1.021
Q6.2_3	Women should renounce their femininity. (3)	1.53	80	1.091	1.28	18	0.958	1.48	98	1.067
Q6.2_4	Women should be less emotional. (4)	2.35	81	1.174	1.83	18	1.043	2.25	99	1.164
Q6.2_5	Women should believe in themselves. (5)	4.7	82	0.537	4.72	18	0.575	4.7	100	0.541
	9. What role did the following play in helping you to overcome the difficulties mentioned above? Never (1) Rarely (2) Sometimes (3) Often (4) All of the Time (5)									
Q4.3_1	Support of peers (1)	3.67	82	1.134	3.72	18	1.074	3.68	100	1.118
Q4.3_2	Support of a manager (2)	3.71	82	1.083	3.44	18	1.294	3.66	100	1.121
Q4.3_3	Support of friends (3)	3.82	82	0.995	3.94	18	1.11	3.84	100	1.012
Q4.3_4	Support of my partner (4)	4.26	81	1.022	4.33	18	0.686	4.27	99	0.967
Q4.3_5	Support of parents (5)	3.98	81	1.193	3.83	18	1.15	3.95	99	1.181
	10. Indicate the extent of your agreement or disagreement by ticking the appropriate box that reflects your opinion about the statement Never (1) Rarely (2) Sometimes (3) Often (4) All of the Time (5)									
Q7.1_1	If you are currently in a STEM career, to what extent would you consider a change of career? (1)	2.19	81	1.05	2.77	13	1.235	2.27	94	1.089

Number	Question	STEM			Non-STEM			Total		
		Mean	N	Standard deviation	Mean	N	Standard deviation	Mean	N	Standard deviation
Q7.1_2	If you are NOT currently in a STEM career, to what extent would you like to return to a STEM career? (2)	3.84	31	1.241	3.14	14	1.167	3.62	45	1.248
Q7.1_3	To what extent do you think women in STEM careers emphasise masculine traits and downplay feminine traits? (3)	2.73	81	0.988	2.47	17	1.007	2.68	98	0.991
	11. To what extent do you agree with the following statements? Never (1) Rarely (2) Sometimes (3) Often (4) All of the Time (5)									
Q7.2_1	Do you think that being a woman made a difference in your career success? (1)	3.15	81	1.097	3.29	17	1.16	3.17	98	1.103
	12. To what extent do the following factors in society's expectation of women prevent them from pursuing STEM careers? Never (1) Rarely (2) Sometimes (3) Often (4) All of the Time (5)									
Q7.3_1	Society believes women cannot do science. (1)	2.86	81	0.959	2.59	17	0.939	2.82	98	0.956
Q7.3_2	Society believes women should not do science. (2)	2.75	81	1.043	2.59	17	1.004	2.72	98	1.033
Q7.3_3	Women should stick to female roles. (3)	2.86	81	1.159	1.82	17	1.237	2.68	98	1.232
Q7.3_4	Society believes that women cannot endure in STEM careers. (4)	2.93	81	1.01	2.88	17	0.993	2.92	98	1.002
	13. To what extent do you think the following factors make it difficult for women to progress in their career? Never (1) Rarely (2) Sometimes (3) Often (4) All of the Time (5)									
Q7.4_1	Insufficient maternity leave (1)	3.35	79	0.975	3.72	18	1.127	3.42	97	1.009
Q7.4_2	Poor salaries (2)	3.3	80	1.06	3.61	18	1.145	3.36	98	1.077
Q7.4_3	Lack of promotion opportunities (3)	3.31	81	1.032	3.67	18	0.97	3.37	99	1.026
Q7.4_4	Competitive environment (4)	3.16	81	0.993	3.22	18	0.878	3.17	99	0.969
Q7.4_5	Women are not regarded as capable managers. (5)	2.94	80	1.083	2.94	18	0.802	2.94	98	1.034
Q7.4_6	Women are not regarded as capable scientists. (6)	2.85	79	1.145	2.83	18	0.985	2.85	97	1.112
Q7.4_7	Office culture is discriminatory against women. (7)	2.83	81	1.149	2.78	18	1.06	2.82	99	1.128

6.5.2 Visual representation of question clusters by STEM status

In this paragraph, the different sections of questions contained in Table 38 are visually presented as line graphs. The means of each question for the two STEM-status groups are graphically represented. The purpose of the visual representation and inspection was to determine whether differences between the two STEM-status group existed in respect of certain items.

Figure 21 depicts the answers to the questions in the role-model section (see the list on page 219). Except for the fact that the non-STEM group's means were slightly lower than those for the STEM group, no significant differences were noted. The answering patterns also revealed the same trend. One might infer a difference in responses between the STEM-status groups, for instance, in the case of Q4.1_5, where a larger than usual gap can be seen between the means of the STEM and non-STEM groups. However, both scores were below 3, indicating that the attendance of science fairs and exhibitions was considered to be of less importance.

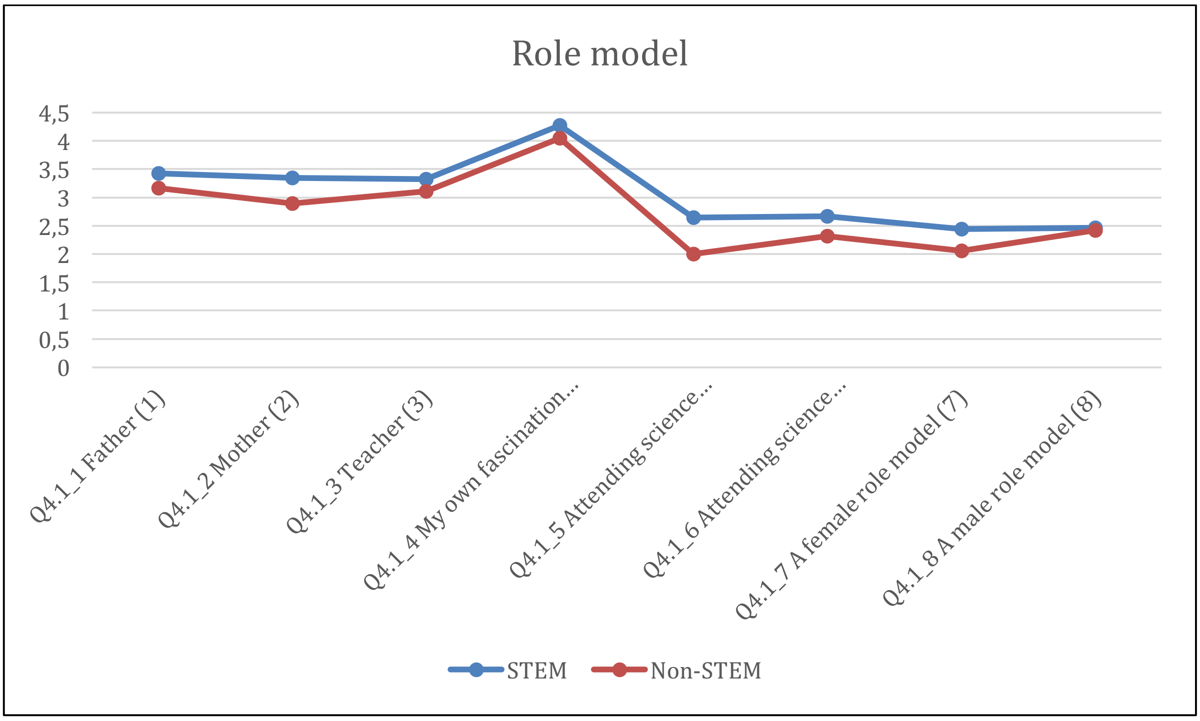

Figure 21 Role model by STEM status

Figure 22 shows the trend for answers on a set of questions answered only by respondents currently involved in STEM fields. Most of the answers were above the midpoint of 3, which indicated overall positive perceptions of their reasons for remaining in STEM. Q4.2_7 had the highest average and indicated the importance of enjoying skills development, while the lowest score was for Q4.2_13.

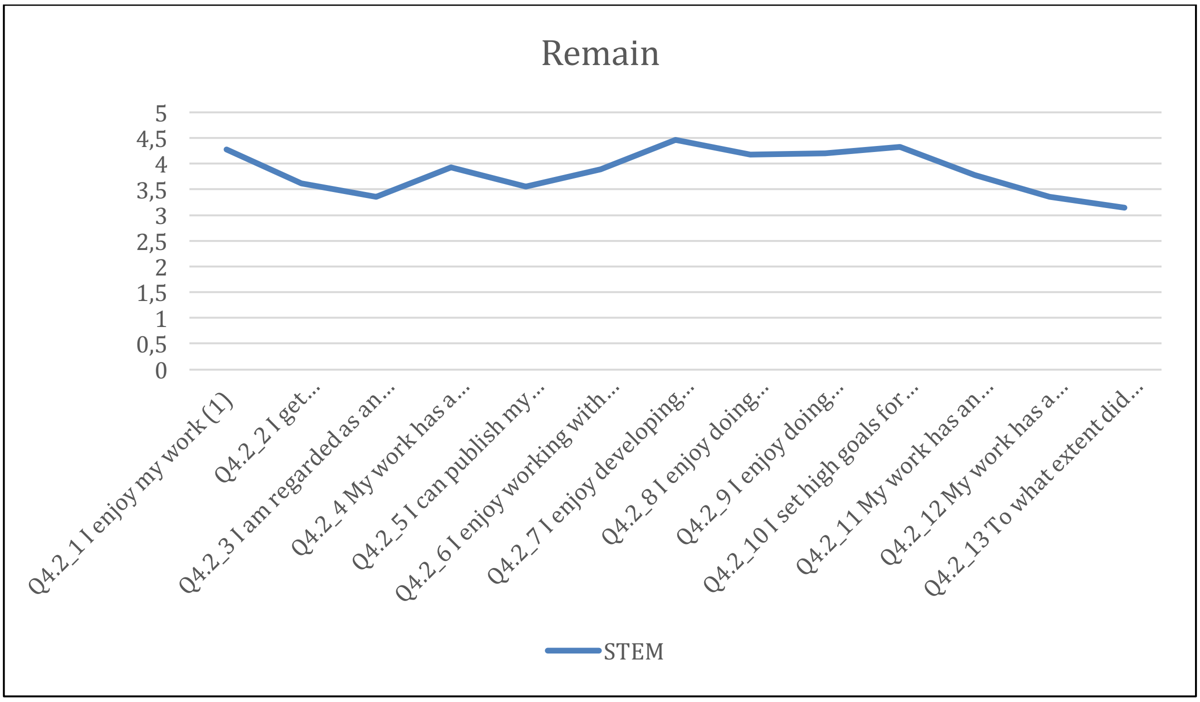

Figure 22 Reasons for STEM incumbents remaining in their fields

Figure 23 shows both groups' perceptions regarding motivators for embarking on STEM studies. The non-STEM group's average scores on were approximately 0.3 below those of the STEM group. For both groups parents and lecturers at university were the most important motivators.

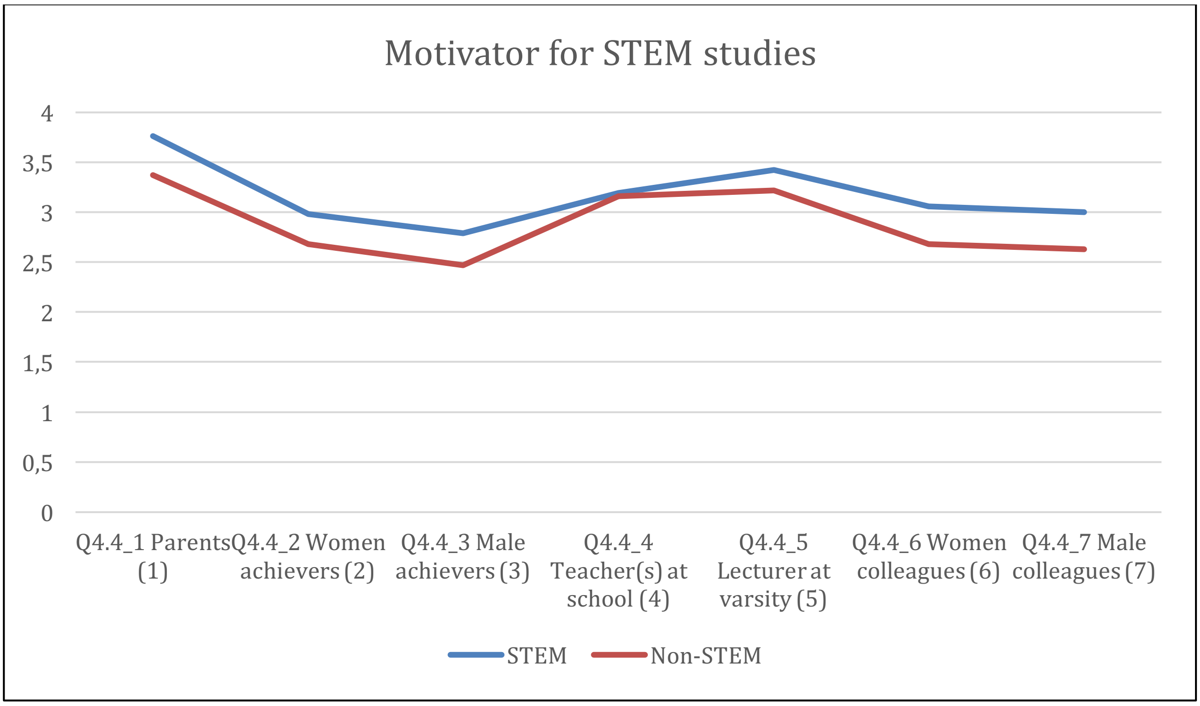

Figure 23 Motivation for studying STEM by STEM status

Figure 24 shows the trends in responses regarding factors that influenced respondents' decisions to participate in STEM. It is interesting to note that the scores were almost identical, except in the case of the last question, where the non-STEM group perceived teachers in a more positive light than did the STEM group.

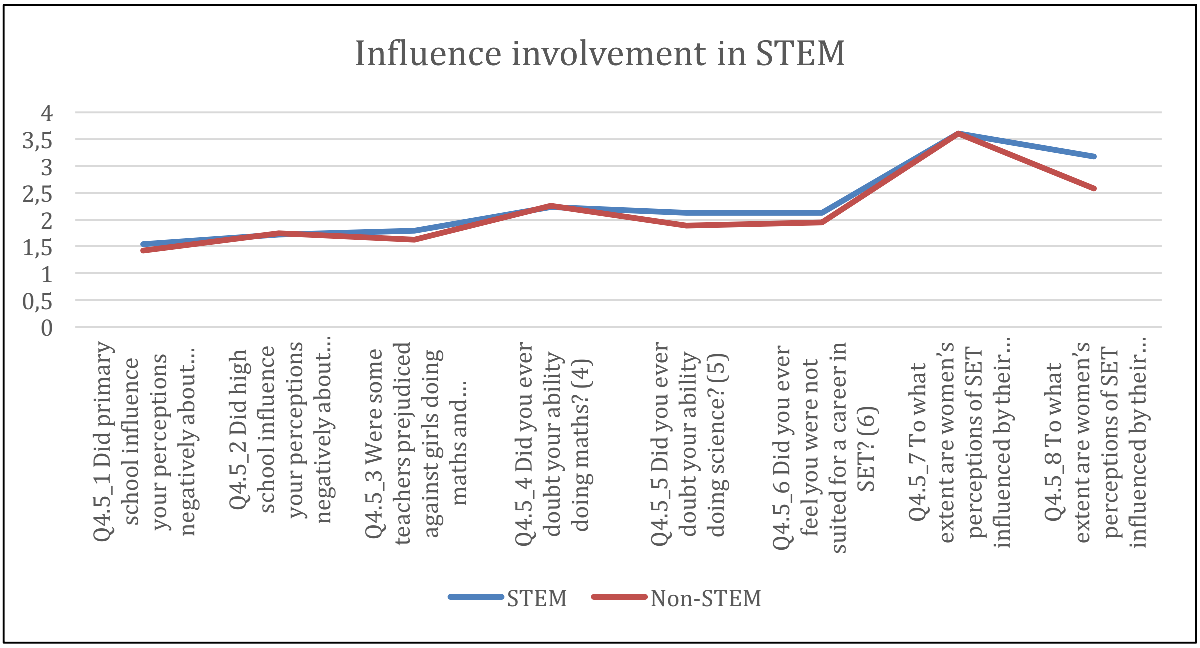

Figure 24 Influences on decisions to enter STEM by STEM status

Figure 25 shows that both groups regarded their own interest in science as the prime motivator for pursuing STEM studies (Q4.6_1). The average score for this question for both groups was above 4, while the scores for the other questions were close to the midpoint of 3.

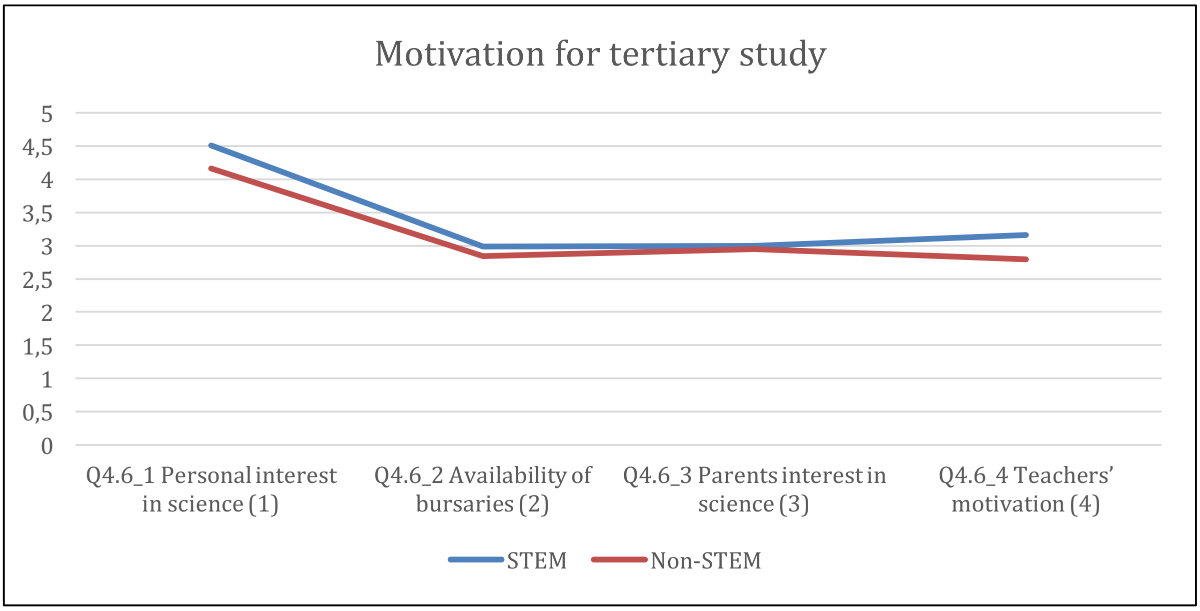

Figure 25 Motivation for STEM tertiary study by STEM status

Figure 26 deals with the first set of barriers experienced at tertiary educational institutions. Since all the scores were below the midpoint. it seems as if the participants did not experience barriers at the tertiary level.

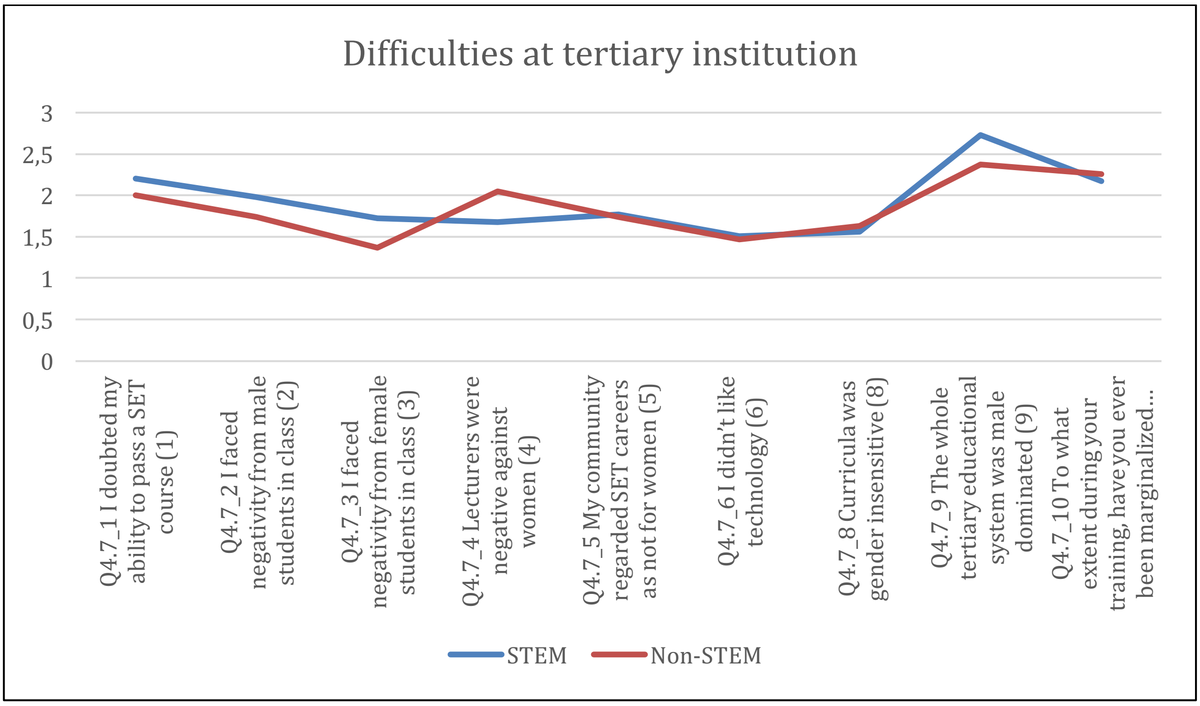

Figure 26 Difficulties experienced at tertiary institutions by STEM status

Figure 27 gives an overview of a large number of barriers experienced by the STEM group. Interesting and prominent deviations occur in the response patterns. It will be informative to look at the gap between group responses, as well as where response scores are below or above the midpoint (3). For instance, in their answers to the question 'Women tend to have a lack of self-confidence', the non-STEM group tended to choose the option 'Rarely', which pointed to a positive regard for women's self-confidence, while the STEM group tended to select 'Often' or the 'above-average' rating. The same tendency can be seen in the case of Q4.7_ 4: 'There is a lack of information on STEM careers'. Non-STEM participants were thus less negative about a lack of STEM information. The same applies to Q4.7_7: 'A gender pay gap' and Q4.7_8: 'Women are not as interested in science as men are'.

The mean scores for most of the questions that were not discussed in the above paragraph were either above or below the midpoint for both the STEM and the non-STEM groups. In order to form an impression of the items above and below the midpoint, a table was constructed to enable a quick view of the content of the magnitude of the mean ratings (Table 39). The items discussed above for which the means for the STEM groups straddled the midpoint were removed from the list of questions in Table 39. The items were ordered, according to their mean scores, from high to low and were repeated in Table 39. It must be noted that Table 39 reports the means of the total sample (N = 108) obtained from Table 38. The items marked in orange were above the midpoint, which means that those issues were experienced as barriers by both groups. The items at the bottom part of the table are marked in yellow and indicate the issues that were not regarded as barriers by either group. The main focus for issues regarded as barriers was on work-life balance and family life. The issues not experienced as barriers focused on workplace discrimination and discriminatory experiences related to the sample's gender.

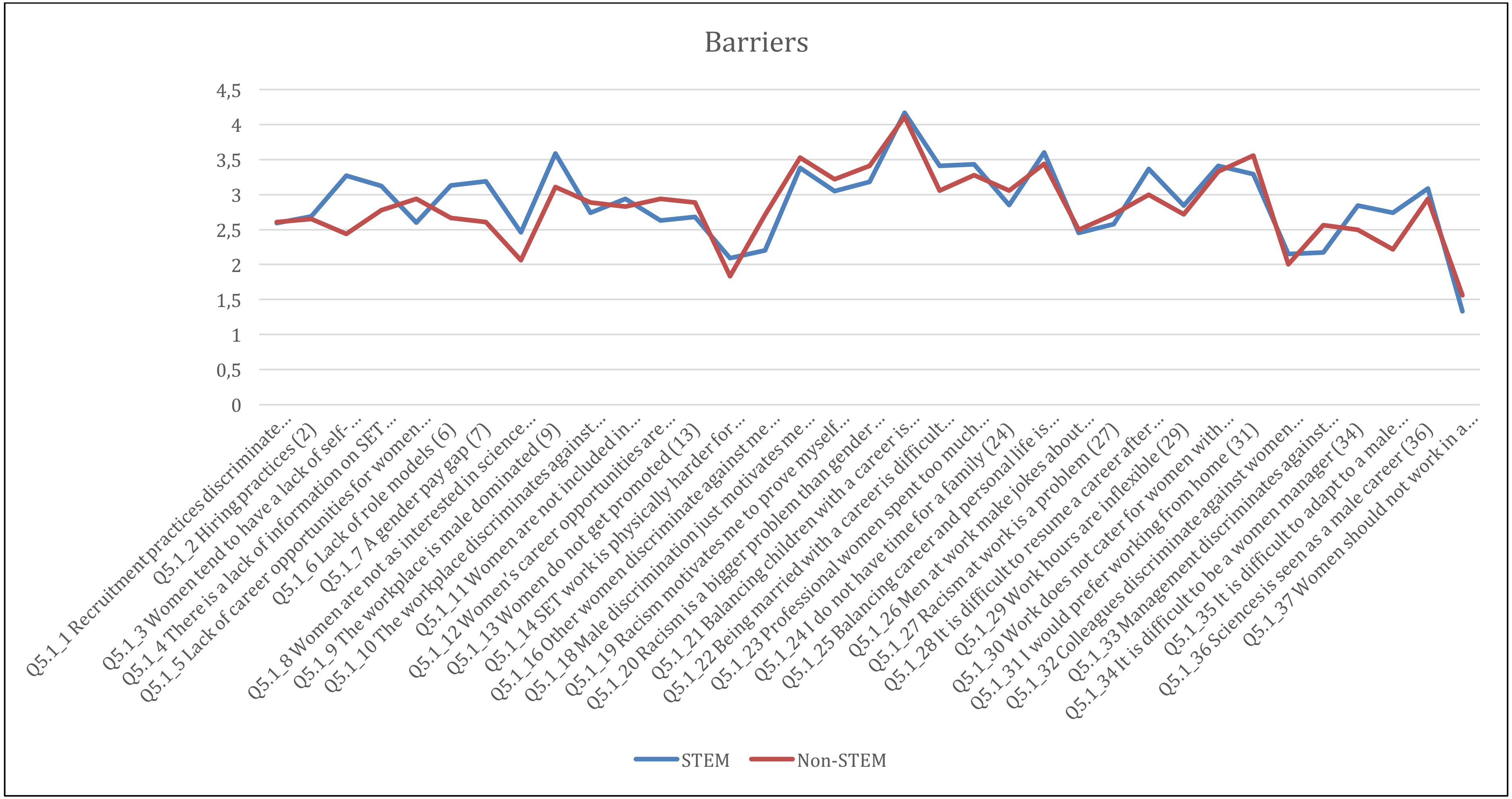

Figure 27 Barriers experienced by STEM status

Table 39 Experience of barriers

Items	N	Minimum	Maximum	Mean	Std. Deviation	Skewness	Std. Error	Kurtosis	Std. Error
Balancing children with a career is difficult. (21)	99	1	5	4.16	0.923	-0.966	0.243	0.499	0.481
Balancing career and personal life is difficult. (25)	101	1	5	3.57	0.92	-0.223	0.24	-0.39	0.476
The workplace is male dominated. (9)	100	1	5	3.5	1.068	-0.558	0.241	-0.043	0.478
Male discrimination just motivates me to work harder. (18)	99	1	5	3.4	1.169	-0.449	0.243	-0.399	0.481
Professional women spend too much time at work. (23)	100	1	5	3.4	1.005	-0.39	0.241	-0.244	0.478
Work does not cater for women with children. (30)	100	1	5	3.4	1.137	-0.337	0.241	-0.632	0.478
Being married and having a career is difficult. (22)	98	1	5	3.35	1.202	-0.376	0.244	-0.683	0.483
I would prefer working from home. (31)	100	1	5	3.34	1.056	-0.25	0.241	-0.205	0.478
It is difficult to resume a career after taking maternity leave. (28)	99	1	5	3.3	0.984	-0.121	0.243	-0.13	0.481
Racism is a bigger problem than gender discrimination. (20)	100	1	5	3.22	1.168	-0.286	0.241	-0.632	0.478
Racism motivates me to prove myself. (19)	100	1	5	3.08	1.461	-0.122	0.241	-1.37	0.478
Science is seen as a male career. (36)	100	1	5	3.06	1.099	-0.4	0.241	-0.552	0.478
Lack of role models (6]	100	1	5	3.05	1.009	-0.102	0.241	-0.3	0.478
Women are not included in management. (11)	100	1	5	2.92	1.07	-0.242	0.241	-0.699	0.478
I do not have time for a family. (24)	100	1	5	2.89	1.154	-0.063	0.241	-0.699	0.478
Work hours are inflexible. (29)	99	1	5	2.82	1.146	0.158	0.243	-0.887	0.481
It is difficult to be a female manager. (34)	99	1	5	2.78	1.121	-0.125	0.243	-0.672	0.481
The workplace discriminates against women. (10)	100	1	5	2.77	0.962	-0.075	0.241	0.079	0.478
Women do not get promoted. (13)	99	1	5	2.72	1.031	0.024	0.243	-0.629	0.481
Women's career opportunities are limited. (12)	100	1	5	2.69	1.042	0.163	0.241	-0.318	0.478
Unfair hiring practices (2)	98	1	5	2.68	0.97	0.4	0.244	0.393	0.483
Lack of career opportunities for women (5)	99	1	5	2.67	0.99	0.265	0.243	-0.215	0.481
It is difficult to adapt to a male-dominated environment. (35)	100	1	5	2.65	0.989	-0.14	0.241	-0.463	0.478

Items	N	Minimum	Maximum	Mean	Std. Deviation	Skewness	Std. Error	Kurtosis	Std. Error
Racism at work is a problem. (27)	98	1	5	2.6	1.164	0.268	0.244	-0.734	0.483
Recruitment practices discriminate against women. (1)	100	1	5	2.59	0.996	0.466	0.241	0.075	0.478
Men at work make jokes about professional women. (26)	101	1	5	2.46	1.204	0.527	0.24	-0.505	0.476
Other women discriminate against me. (17)	100	1	5	2.29	1.038	0.386	0.241	-0.538	0.478
Management discriminates against women. (33)	100	1	5	2.24	1.046	0.583	0.241	-0.165	0.478
Colleagues discriminate against women. (32)	100	1	5	2.12	1.047	0.832	0.241	0.406	0.478
STEM work is physically harder for women. (14)	99	1	4	2.04	0.88	0.379	0.243	-0.716	0.481
Women should not work in a technological environment. (37)	97	1	4	1.37	0.74	2.107	0.245	3.884	0.485

Figure 28 shows the two groups' beliefs about how barriers could be overcome. First of all, women from both groups strongly believed that the existing barriers could be overcome. To a large extent the STEM group regarded how hard women work (Q6.2_2) as an enabling factor. Self-belief (Q6.2_5) was regarded as very important for both groups. Note that renouncing femininity (Q6.2_3) and being less emotional (Q6.2_4) seemed to be less important in overcoming barriers.

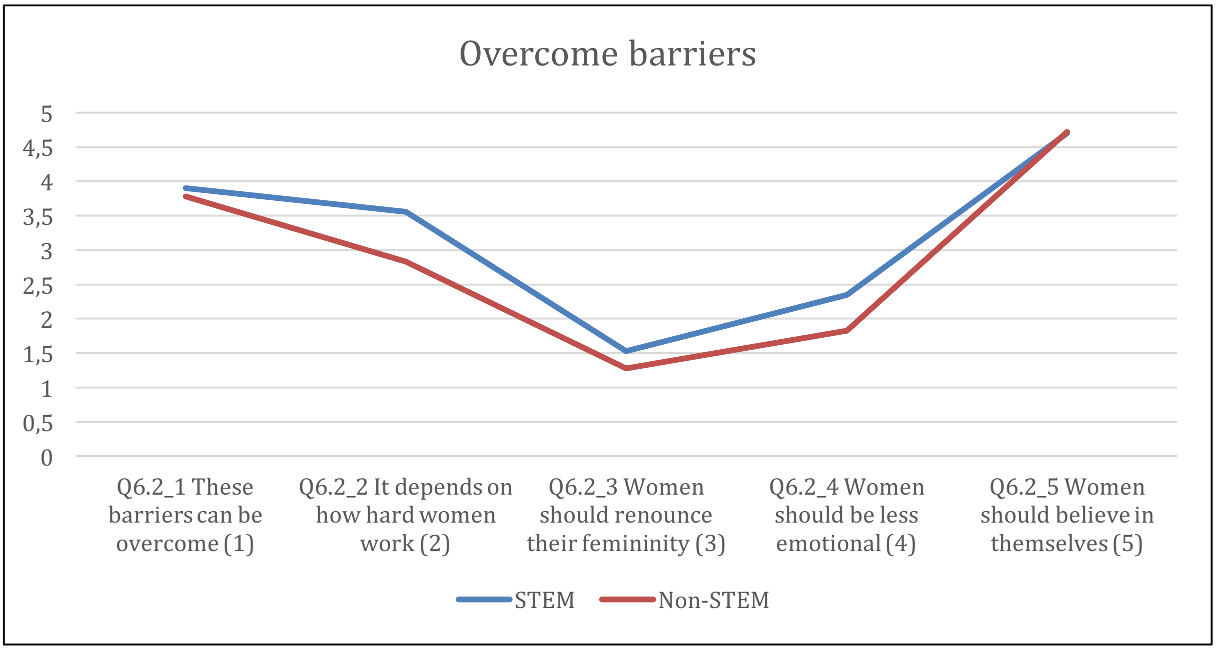

Figure 28 Beliefs about overcoming barriers by STEM status

With regard to support for overcoming barriers, Figure 29 shows that the support received from peers, managers, friends, partners and parents plays an important in overcoming the barriers.

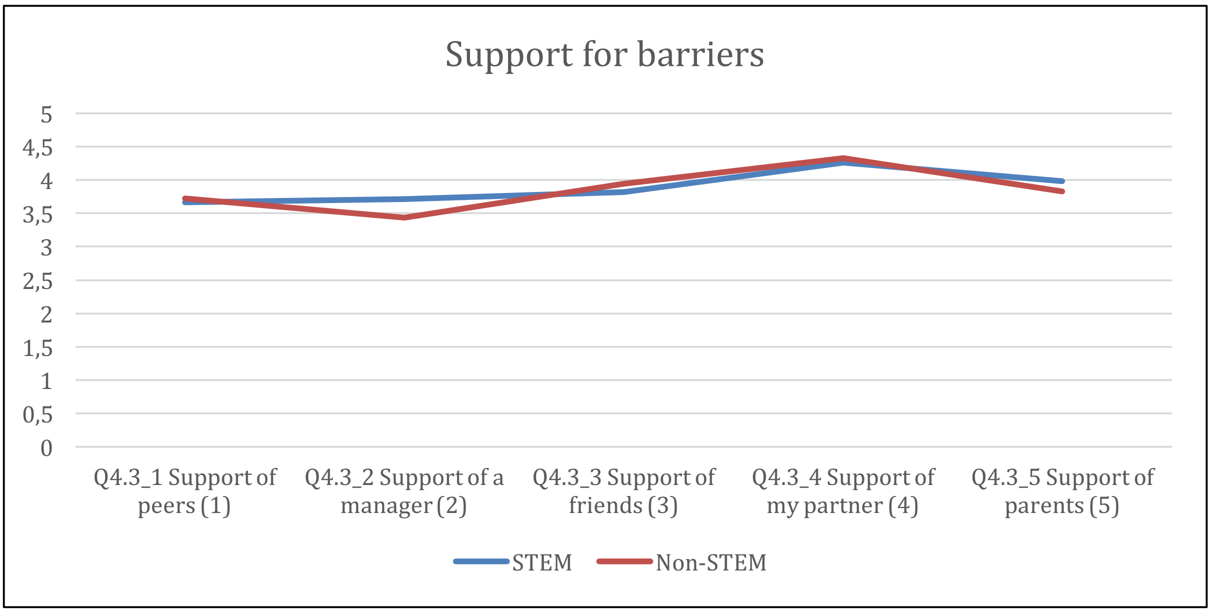

Figure 29 Support for overcoming STEM barriers by STEM status

Figure 30 shows the results for some question that did not fit within the sections discussed above (see the list in paragraph 6.5), but explored issues pertinent to STEM. The questions were:

a. If you are currently in a STEM career, to what extent would you consider a change of career?
b. If you are NOT currently in a STEM career, to what extent would you like to return to a STEM career?
c. To what extent do you think women in STEM careers emphasise masculine traits and downplay feminine traits?
d. Do you think that being a woman made a difference in your career success?

Neither group considered a current change in career and respondents in the STEM group indicated that they would return to STEM if they ever left the field. The non-STEM group's responses to this question were non-committal. Similar perceptions (close to the midpoint) were found in the responses to the question about an emphasis on masculine traits in STEM careers and the question about whether being a woman makes a difference.

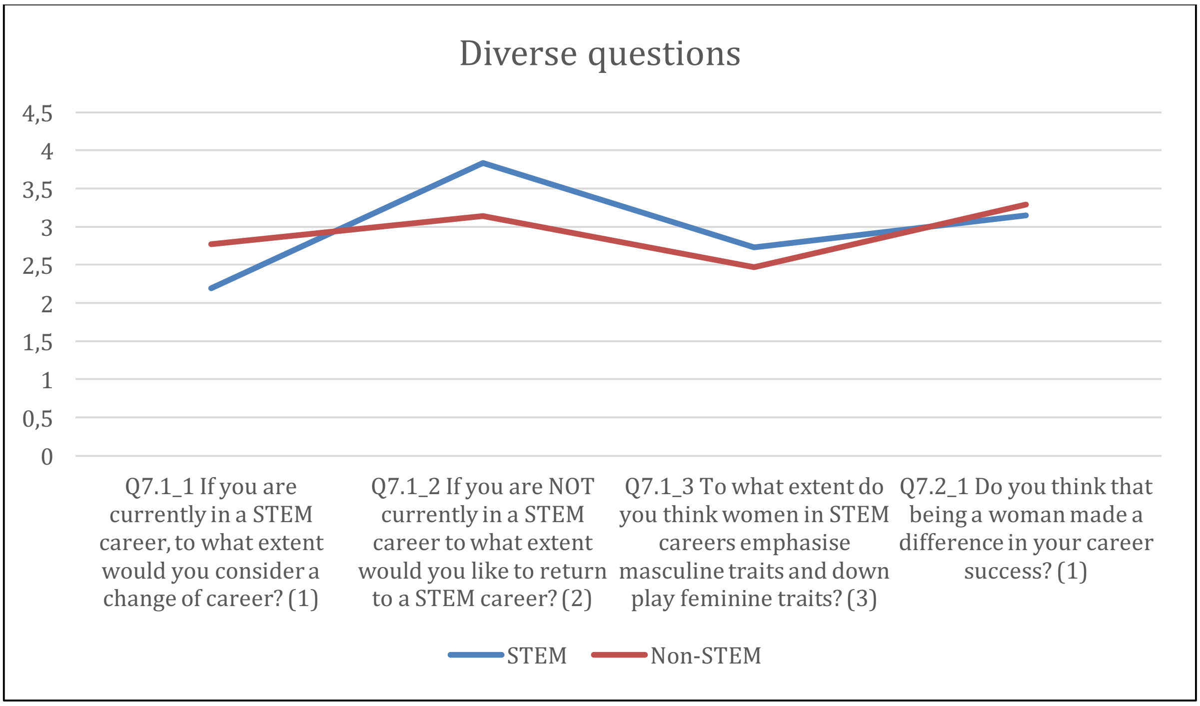

Figure 30 Diverse questions by STEM status

In terms of societal expectations,

Figure 31 shows responses close to the midpoint. The non-STEM group did not think that society expects women to focus on female roles (Q7.3_3).

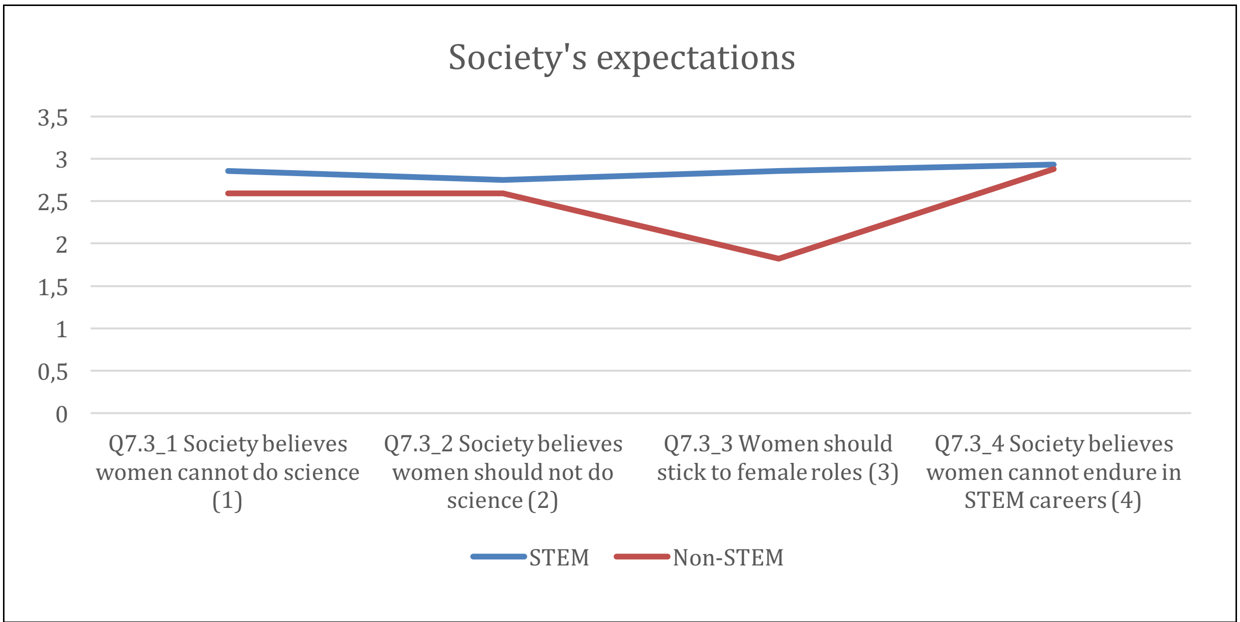

Figure 31 Societal expectations for women by STEM status

Some of the factors that played a role in problems experienced by women and made it difficult for them to remain in STEM were explored and the findings are depicted in Figure 32. Issues that both groups regarded as problematic were maternity leave, salaries and lack of promotion. They did not have an issue with perceptions about the managerial ability of women, their capability as scientists, or that office culture discriminates against women.

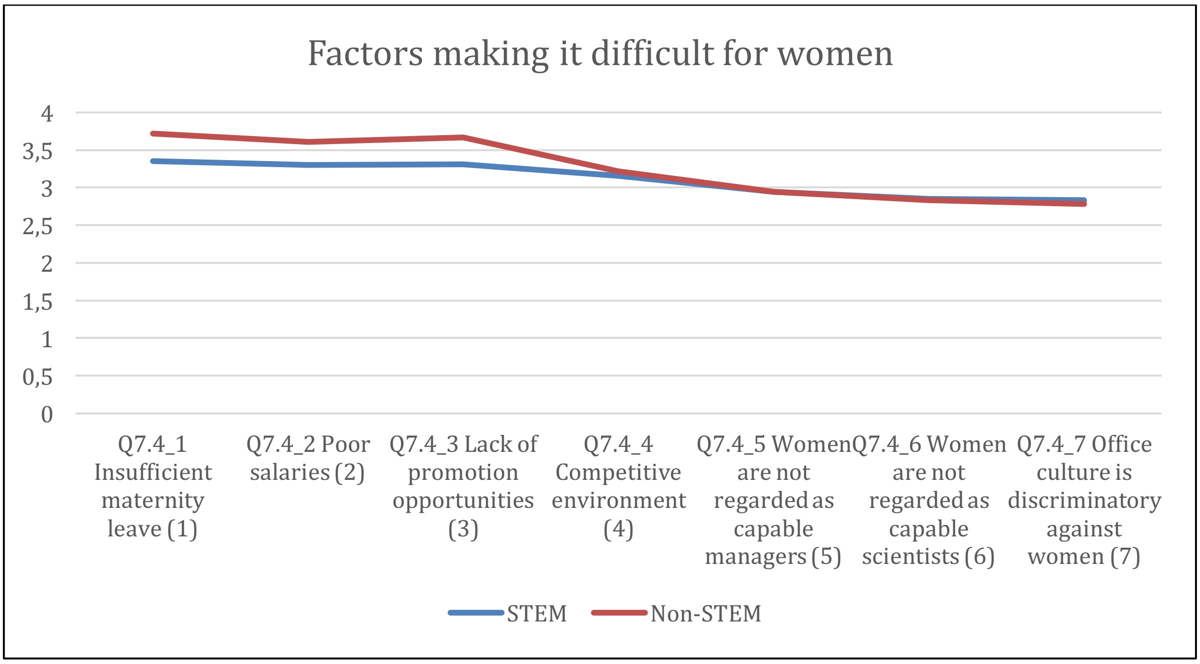

Figure 32 Factors that make it difficult for women to remain in STEM by STEM status

In the next paragraph the 94 items of the EQ are subjected to an exploratory factor analysis in order to reduce the number of items to a manageable set. These factors will be used to determine whether the two STEM-status groups differ in respect of contextual issues. The aim, as discussed in Chapter 4, is to construct a logistic regression model with, amongst others, the factors identified in the exploratory factor analysis.

6.5.3 Data reduction of the Exploratory Questionnaire (EQ): Factor analysis

In this paragraph the items of the EQ are explored by way of a factor analysis or principal component analysis (PCA) to reduce the number of items to a manageable few latent variables or factors (or components) in order to be able to compare the STEM groups and construct a model for predicting group membership (paragraph 6.6 below). The specific technique used in this study is a principal component analysis, and when reference is made to factors or factor analysis, components or PCA are intended (Field, 2013, pp. 675-676).

Provided that the sample size to item number ratio was adequate, the 94 items of the EQ could be included in one PCA. However, Pallant (2011, p. 187) maintains that the sample size should be five times the number of items, which means that in this case a sample of 450 respondents would have been required. However, if smaller packets of items are used for a factor analysis, one can analyse at least 20 items at a time. Choosing which items to group together in a packet can be difficult as numerous combinations are possible. One way to do this is to take the sections in the EQ as basis. However, one might miss items in sections that could load on different factors. A tentative solution is to factor-analyse all the items without regard for any restrictions and requirements in order to obtain five 'packets' that each contain items that correlate highly with each other. These five packets of items are then analysed separately by using a PCA and with the usual requirements and restrictions in place (see Chapter 4). One thus has smaller packets, preferably with 20 items each, or less, that can be analysed. One could call the establishment of these five packets as a *heuristic PCA* in order to not confuse it with the actual five PCAs on groups of items. As indicated below (paragraph 6.5.3.1), the eventual number of packets that provided a meaningful grouping of items was four, rather than five, as some of the packets became very small and contained only five factors.

The four groupings of items were each subjected to a PCA. For each PCA the sample size, determinant, sample adequacy, the communality distribution of items and the rotated component matrix were reported, as discussed in Chapter 4. The number of factors were based on the inflection point of the scree-test. As mentioned in Chapter 4, all the analyses

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employed the Varimax rotation with Kaiser normalisation to force factors to be uncorrelated so that component structures could be clearly shown.

In the next paragraph the results of the heuristic PCA will be provided. Thereafter, the four PCAs for the groupings or packets of items will be discussed.

6.5.3.1 Heuristic PCA

The heuristic PCA provided an approximate indication of items that correlated with each other. There were 94 items and the sample size was 108. The requirements for sampling adequacy, multicolinearity and the magnitude of the correlations were discussed in Chapter 4. In this case, the poor sample to item ratio was evident from the inadequate indices. (a) The determinant was 8.713E-53, which was smaller than 0.00001 and means that multicollinearity might be present (Field, 2013, p. 686). (b) The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was .32. It should be closer to 1, but larger than 0.5; the observed value is mediocre, which means that correlations might not yield distinct factors (Field, 2013, p. 684). (c) Bartlett's test of sphericity approximate Chi-Square was 7292.228, (*df* = 4371, *p* = .00). Unless it is significant, correlations might be too small (Field, 2013, p. 685).

A visual inspection of the approximate normality of distributions showed that the following items were very skew: Q6.2_5, Q6.2_3, Q5.1_37, Q4.7_8, Q4.7_6, Q4.6_1, Q4.5_3, Q4.5_2 and Q4.5_1. One would expect these items to show other problems, such as low communalities. However, it must be noted that it does not necessarily mean that an item was poorly worded or misunderstood. Respondents merely could have uniformly disagreed, which is a valid response but means that the item will not fit very well into a factor.

According to Field (2013, p. 684), if the sample is small or the sample to item ratio is inadequate, one could still do a PCA when the communalities of items are above .6. To enable an assessment of this requirement, a frequency table was constructed for items that indicated their communality distribution within categories from 0 to .9. As seen in Table 40, only 22% of the items had a communality of .6 or above. The small number of items with communalities of .6 and above also precludes a valid PCA. The communality distribution for the four PCAs will also be done below to indicate the adequacy of the PCAs. Unless many items have communalities of .6 and above, not much confidence can be placed in the stability of the factor structure.

Table 40 Communality distribution for exploratory PCA

Category	Frequency	Percentage
0	0	0.00
0.1	5	0.05
0.2	10	0.11
0.3	14	0.15
0.4	23	0.24
0.5	21	0.22
0.6	18	0.19
0.7	2	0.02
0.8	1	0.01
0.9	0	0.00
Total	94	100

Table 41 The rotated component matrix of the heuristic PCA

Rotated component matrix[a]	Component			
	1	2	3	4
Q7.4_6 Women are not regarded as capable scientists. (6)	0.82			-0.15
Q5.1_13 Women do not get promoted. (13)	0.76			
Q5.1_35 It is difficult to adapt to a male-dominated environment. (35)	0.76		0.22	
Q7.3_1 Society believes that women cannot do science. (1)	0.73			-0.12
Q7.3_4 Society believes that women cannot endure in STEM careers. (4)	0.73	0.13	0.15	
Q7.3_2 Society believes that women should not do science. (2)	0.72			
Q5.1_32 Colleagues discriminate against women. (32)	0.72		0.15	
Q5.1_12 Women's career opportunities are limited. (12)	0.69		0.16	
Q5.1_34 It is difficult to be a female manager. (34)	0.69		0.11	-0.19
Q5.1_10 The workplace discriminates against women. (10)	0.69		0.24	0.11
Q7.4_5 Women are not regarded as capable managers. (5)	0.69	0.12		-0.34
Q4.7_10 To what extent were you marginalised during your training because you are a woman? (10)	0.68			
Q5.1_33 Management discriminates against women. (33)	0.67		0.15	0.20
Q5.1_36 Science is seen as a male career. (36)	0.67		0.17	
Q5.1_26 Men at work make jokes about professional women. (26)	0.67		0.19	
Q7.4_7 Office culture is discriminatory against women. (7)	0.65		0.25	
Q5.1_11 Women are not included in management. (11)	0.65			
Q5.1_7 A gender pay gap (7)	0.64	0.11	0.21	
Q7.4_3 Lack of promotion opportunities (3)	0.63			
Q5.1_9 The workplace is male dominated. (9)	0.62			
Q4.7_5 My community regarded STEM careers as not for women. (5)	0.61			
Q5.1_2 Hiring practices (2)	0.58		0.22	0.15
Q5.1_5 Lack of career opportunities for women (5)	0.56			0.34

Rotated component matrix[a]	Component			
	1	2	3	4
Q4.7_4 Lecturers were negative towards women. (4)	0.54	-0.10		
Q5.1_1 Recruitment practices discriminate against women. (1)	0.53		0.28	0.15
Q4.5_3 Were some teachers prejudiced against girls doing maths and science? (3)	0.53		0.13	
Q7.4_2 Poor salaries (2)	0.53		0.15	0.21
Q4.7_2 I faced negativity from male students in class. (2)	0.51		0.14	
Q5.1_18 Male discrimination just motivates me to work harder. (18)	0.49		-0.15	-0.25
Q5.1_6 Lack of role models (6)	0.48		-0.15	0.28
Q4.7_3 I faced negativity from female students in class. (3)	0.47			
Q4.7_8 Curricula were gender insensitive. (8)	0.47		-0.16	0.25
Q7.3_3 Women should stick to female roles. (3)	0.45		0.36	
Q5.1_16 Other women discriminate against me. (17)	0.44	-0.12	-0.17	
Q4.7_9 The whole tertiary educational system was male dominated. (9)	0.44			0.16
Q7.4_4 Competitive environment (4)	0.42	0.23		-0.36
Q5.1_4 There is a lack of information on STEM careers. (4)	0.41		-0.26	0.26
Q4.5_8 To what extent are women's perceptions of STEM influenced by their teachers in a negative way? (8)	0.38		0.11	0.21
Q5.1_27 Racism at work is a problem. (27)	0.38			
Q5.1_19 Racism motivates me to prove myself. (19)	0.38	0.22	-0.28	-0.27
Q7.1_3 To what extent do you think women in STEM careers emphasise masculine traits and downplay feminine traits? (3)	0.33	0.18	0.16	-0.14
Q5.1_14 STEM work is physically harder for women.(14)	0.32			-0.17
Q7.2_1 Do you think that being a woman made a difference in your career success? (1)	0.32		0.12	-0.29
.Q5.1_8 Women are not as interested in science as men are. (8)	0.23	0.22		-0.23
Q5.1_37 Women should not work in a technological environment. (37)	0.23		0.17	
Q4.4_6 Women colleagues (6)		0.74		0.15
Q4.4_4 Teacher(s) at school (4)	-0.18	0.71		
Q4.4_3 Male achievers (3)	0.15	0.70		-0.12
Q4.4_7 Male colleagues (7)		0.69	-0.11	0.30
Q4.1_3 Teacher (3)		0.68		
Q4.4_2 Female achievers (2)	0.24	0.68		
Q4.4_1 Parents (1)		0.68	-0.14	-0.13
Q4.1_7 A female role model (7)	0.22	0.63		
Q4.4_5 Lecturer at varsity (5)	-0.17	0.63		0.25
Q4.1_2 Mother (2)		0.62	-0.25	-0.13
Q4.6_4 Teachers' motivation (4)	-0.25	0.60	0.16	
Q4.1_6 Attending science programmes at institutions (6)		0.58		-0.18
Q4.1_8 A male role model (8)		0.57		-0.14
Q4.3_5 Support of parents (5)	0.14	0.54	-0.32	-0.12
Q4.6_3 Parents' interest in science (3)		0.52		-0.23
Q4.1_1 Father (1)	-0.10	0.50		-0.24

Rotated component matrix[a]	Component			
	1	2	3	4
Q4.1_5 Attending science fairs/exhibitions (5)		0.50	-0.11	-0.37
Q4.1_4 My own fascination with science (4)	-0.11	0.48	0.14	-0.17
Q4.3_3 Support of friends (3)	0.13	0.44	-0.22	0.25
Q4.3_2 Support of a manager (2)		0.39		0.33
Q4.6_1 Personal interest in science (1)		0.39	0.24	
Q5.1_31 I would prefer working from home, (31)		-0.37	0.16	
Q4.3_4 Support of my partner (4)	0.17	0.31	-0.14	-0.13
Q6.2_1 These barriers can be overcome, (1)				
Q5.1_25 Balancing career and personal life is difficult, (25)	0.24		0.71	
Q5.1_21 Balancing children with a career is difficult, (21)			0.70	
Q5.1_30 Work does not cater for women with children. (30)	0.20	-0.22	0.65	0.14
Q5.1_24 I do not have time for a family. (24)		-0.16	0.62	
Q5.1_23 Professional women spend too much time at work. (23)	0.15	-0.11	0.61	-0.33
Q5.1_29 Work hours are inflexible. (29)	0.15		0.57	
Q5.1_22 Being married and having a career is difficult. (22)	0.33	0.13	0.54	
Q5.1_28 It is difficult to resume a career after taking maternity leave. (28)	0.22		0.52	
Q7.4_1 Insufficient maternity leave (1)	0.16		0.52	0.24
Q5.1_20 Racism is a bigger problem than gender discrimination. (20)	0.14		-0.33	
Q5.1_3 Women tend to lack self-confidence. (3)	0.26	0.15	0.27	0.24
Q4.6_2 Availability of bursaries (2)	0.12		0.18	
Q4.7_6 I didn't like technology. (6)	0.11	-0.10	0.11	-0.11
Q4.5_4 Did you ever doubt your ability to do maths? (4)	0.23	-0.20	0.15	0.57
Q4.3_1 Support of peers (1)		0.37	-0.17	0.54
Q4.5_6 Did you ever feel you were not suited for a career in STEM? (6)	0.24	-0.15	0.13	0.51
Q4.5_5 Did you ever doubt your ability to do science? (5)	0.16	-0.17		0.50
Q4.5_2 Did high school negative affect your perceptions about science? (2)	0.26		0.15	0.48
Q6.2_2 It depends on how hard women work (2)	0.14	0.21		-0.45
Q4.5_1 Did primary school negatively affect your perceptions negatively about science? (1)	0.32		0.14	0.41
Q6.2_4 Women should be less emotional. (4)	0.13	0.18	-0.12	-0.40
Q6.2_3 Women should renounce their femininity. (3)	0.20			-0.36
Q4.7_1 I doubted my ability to pass a STEM course. (1)	0.22			0.31
Q4.5_7 To what extent are women's perceptions of STEM influenced by their teachers in a positive way? (7)		0.27		0.28
Q6.2_5 Women should believe in themselves, (5)		0.14		-0.21
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalisation. a. Rotation converged in five iterations.				

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As expected, the first factor or component consisted of a large number of items, despite the Varimax rotation (Table 41). Without too much interpretation (i.e., trying to label factors or finding sense in the groupings of items) the four clusters of items will be independently analysed in the paragraphs that follow.

6.5.3.2 Principal Component Analysis 1 (PCA 1)

The indices for PCA 1 were as follows:

a. Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy = .787. Closer to 1 and larger than 0.5, as in this case, means that the PCA can yield distinct factors (Field, 2013, p. 684).
b. Bartlett's Test of Sphericity Approximate Chi-Square = 1162.163 (df = 253, p = .000). The correlation matrix differs significantly from an identity matrix, thus correlations are large enough for a PCA (Field, 2013, p. 685).
c. The determinant = 1.71E-006. The determinant of the R-matrix should be larger than 0.00001 to show that no-multicollinearity is present (Field, 2013, p. 686). In this instance it is small (0.00000171), which indicates possible multicollinearity.
d. The communalities for the items are much better than previously, even though not yet excellent. Table 42: 43% of the communalities were above .6 and 39% were between .3 and .5. Four items of 17% were in the region of .2, and one would not expect these items to load adequately on any component.

Table 42 Communality distribution for PCA 1

Category	Frequency	Percentage
0	0	0.00
0.1	0	0.00
0.2	4	0.17
0.3	2	0.09
0.4	5	0.22
0.5	2	0.09
0.6	7	0.30
0.7	2	0.09
0.8	1	0.04
0.9	0	0.00
Total	23	100

The scree-plot indicated two factors and the loadings can be seen in Table 43. The items that were deleted due to low communality or a too low loading are flagged by footnotes b. and c.

in the table. An attempt was made to retain items larger than 0.3 in a factor if two previous conditions were not met. If, with regard to content, an item did not make any sense in its particular context it was also deleted, except in cases where the loading was high (larger than .4 or .5) but did not have a low communality. One item was deleted and factors 1 and 2 had 12 and 10 items respectively. The two factors were labelled as:

a. External relationships/persons motivated the respondent to embark on a STEM career
b. Significant relationships motivated the respondent to embark on a STEM career.

Table 43 The rotated component matrix for PCA 1

Items	External relationships/persons motivated the respondent to embark on a STEM career	Significant relationships motivated the respondent to embark on a STEM career
Q4.4_6 Women colleagues (6)	.770	.218
Q4.4_5 Lecturer at varsity (5)	.734	
Q4.4_7 Male colleagues (7)	.688	.252
Q4.4_4 Teacher(s) at school (4)	.680	.318
Q4.4_2 Women achievers (2)	.660	.302
Q4.4_3 Male achievers (3)	.608	.404
Q4.1_3 Teacher (3)	.602	.361
Q4.1_7 A female role model (7)	.585	.311
Q4.6_4 Teachers' motivation (4)	.580	.230
Q4.3_3 Support of friends (3)	.470	
Q4.3_2 Support of a manager (2)[c]	.448	
Q4.1_8 A male role model (8)	.439	.393
Q4.4_1 Parents (1)	.205	.817
Q4.1_2 Mother (2)	.188	.770
Q4.1_1 Father (1)		.760
Q4.6_3 Parents' interest in science (3)		.754
Q4.3_5 Support of parents (5)	.237	.564
Q4.1_5 Attending science fairs/exhibitions (5)	.284	.496
Q4.1_6 Attending science programmes at institutions (6)	.396	.464
Q5.1_31 I would prefer working from home. (31)[b c]	-.161	-.397
Q4.1_4 My own fascination with science (4)	.328	.381
Q4.6_1 Personal interest in science (1)[c]	.213	.337
Q4.3_4 Support of my partner (4)[c]	.162	.292

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalisation.[a]
a. Rotation converged in three iterations.
b. Remove item from factor score
c. Low communality

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6.5.3.3 Principal Component Analysis 2 (PCA 2)

PCA 2 yielded the following indices:

a. Kaiser-Meyer-Olkin measure of sampling adequacy = .823. Distinct factors were possible.
b. Bartlett's Test of sphericity approximate Chi-Square = 2802.066, (df = 990, p = .000). Correlations between items were large enough for a factor analysis.
c. Determinant = 1.41E-018 thus possible multicollinearity was present.
d. Communality distribution in Table 44 shows: 52% of the items had a communality of .6 and higher.

Table 44 Communality distribution for PCA 2

Category	Frequency	Percentage
0	0	0.00
0.1	2	0.04
0.2	3	0.07
0.3	5	0.11
0.4	5	0.11
0.5	6	0.13
0.6	14	0.31
0.7	8	0.18
0.8	2	0.04
0.9	0	0.00
Total	45	100

Table 45 Rotated component matrix of PCA 2

	Societal and workplace culture barriers	Barriers of formal organisational structures	Educational barriers such as gender and racial discrimination
Q5.1_2 Hiring practices (2)	.741	.253	
Q5.1_10 The workplace discriminates against women. (10)	.734	.444	
Q7.3_2 Society believes women should not do science. (2)	.726		.427
Q5.1_1 Recruitment practices discriminate against women. (1)	.712	.206	
Q7.3_4 Society believes women cannot endure in STEM careers. (4)	.669	.117	.438
Q7.4_7 Office culture is discriminatory against women. (7)	.660	.255	.225
Q5.1_12 Women’s career opportunities are limited. (12)	.641	.513	

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	Societal and workplace culture barriers	Barriers of formal organisational structures	Educational barriers such as gender and racial discrimination
Q5.1_35 It is difficult to adapt to a male-dominated environment. (35)	.622	.314	.419
Q5.1_36 Science is seen as a male career. (36)	.592	.250	.309
Q7.3_3 Women should stick to female roles. (3)	.589	-.141	.269
Q7.4_6 Women are not regarded as capable scientists. (6)	.586	.359	.459
Q5.1_33 Management discriminates against women. (33)	.538	.409	.231
Q7.3_1 Society believes women cannot do science. (1)	.526	.186	.479
Q5.1_9 The workplace is male dominated. (9)	.503	.492	
Q4.5_8 To what extent are women's perceptions of STEM influenced by their teachers in a negative way? (8)	.476		.231
Q7.4_5 Women are not regarded as capable managers. (5)	.468	.366	.303
Q5.1_32 Colleagues discriminate against women. (32)	.453	.417	.436
Q7.1_3 To what extent do you think women in STEM careers emphasise masculine traits and downplay feminine traits? (3) [c]	.304	.132	
Q5.1_37 Women should not work in a technological environment. (37) [c]	.241		
Q5.1_13 Women do not get promoted. (13)	.480	.648	.216
Q7.4_2 Poor salaries (2)	.265	.621	.166
Q5.1_11 Women are not included in management. (11)	.410	.621	
Q7.4_3 Lack of promotion opportunities (3)	.344	.609	.139
Q5.1_7 A gender pay gap (7)	.387	.588	.193
Q5.1_5 Lack of career opportunities for women (5)	.434	.587	
Q5.1_6 Lack of role models (6)	.162	.574	
Q5.1_16 Other women discriminate against me. (17)		.526	.342
Q5.1_4 There is a lack of information on STEM careers. (4)		.512	.103
Q5.1_34 It is difficult to be a women manager (34)	.311	.506	.433
Q7.4_4 Competitive environment (4)	.106	.402	.240
Q5.1_14 STEM work is physically harder for women. (14) [c]		.378	.186
Q7.2_1 Do you think that being a woman made a difference in your career success? (1) [c]		.333	.211
Q4.7_4 Lecturers were negative towards women. (4)	.165		.755
Q4.7_5 My community regarded STEM careers as not for women. (5)	.360		.737
Q4.7_3 I faced negativity from female students in class. (3)	.103	.159	.652
Q4.7_2 I faced negativity from male students in class. (2)	.193	.142	.646

	Societal and workplace culture barriers	Barriers of formal organisational structures	Educational barriers such as gender and racial discrimination
Q4.7_8 Curricula were gender insensitive. (8)		.166	.553
Q4.5_3 Were some teachers prejudiced against girls doing maths and science? (3)	.487		.546
Q5.1_26 Men at work make jokes about professional women. (26)	.380	.345	.510
Q4.7_9 The whole tertiary education system was male dominated. (9)	.268	.142	.507
Q4.7_10 To what extent during your training were you marginalised because you are a woman? (10)	.452	.312	.483
Q5.1_19 Racism motivates me to prove myself. (19)	-.151	.310	.472
Q5.1_27 Racism at work is a problem. (27)		.213	.404
Q5.1_18 Male discrimination just motivates me to work harder. (18)	.150	.307	.345
Q5.1_8 Women are not as interested in science as men are. (8) [bc]		.113	.178

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalisation.[a]
a. Rotation converged in 18 iterations.
b. Remove item from factor score.
c. Low communality

Contrary to the requirement of 20-item packets discussed on page 238, this packet had 45 items. The indices discussed on page 245 above nevertheless allowed a PCA to be done. Three factors were extracted based on the screen-plot inflection point. Table 45 shows the component matrix loadings for PCA 2. One item was deleted from factor scores. Factor 1 had 18 items, Factor 2 had 13 and Factor 3 had 12.

Considering the content of the items for each of the three factors, the following labels were chosen:

a. Societal and workplace culture barriers
b. Barriers of formal organisational structures
c. Educational barriers such as gender and racial discrimination

6.5.3.4 Principal Component Analysis 3 (PCA 3)

PCA 3 yielded the following indices:

a. Kaiser-Meyer-Olkin measure of sampling adequacy = .793, thus distinct factors were possible.

b. Bartlett's Test of sphericity approximate Chi-Square = 338.983, (df = 78, p = .000), thus correlations were large enough for a PCA.
c. Determinant = .022, thus no multi-collinearity between items was present.
d. Table 46 shows that 32% of the items had communalities of .6 and above, while 76% were between .3 and .5. Although the communalities were not too low, they were not good.

Table 46 Communality distribution for PCA 3

Category	Frequency	Percentage
0	0	0.00
0.1	1	0.08
0.2	0	0.00
0.3	1	0.08
0.4	2	0.15
0.5	5	0.38
0.6	3	0.23
0.7	1	0.08
0.8	0	0.00
0.9	0	0.00
Total	13	100

Table 47 shows the results for PCA 3. Two factors were extracted based on the scree-plot, and two items on the first component were deleted. Factor 1 had 6 items and Factor 2 had 4 items. The labels for the two factors were:

a. Work-life balance difficulty
b. Personal discomfort

Table 47 Rotated component matrix for PCA 3

	Difficulty to balance work and life	Personal discomfort
Q5.1_25 Balancing career and personal life is difficult. (25)	.727	.304
Q5.1_30 Work does not cater for women with children. (30)	.698	.227
Q5.1_23 Professional women spend too much time at work. (23)	.682	.158
Q5.1_24 I do not have time for a family. (24)	.679	
Q5.1_29 Work hours are inflexible. (29)	.655	
Q5.1_21 Balancing children with a career is difficult. (21)	.569	.468
Q5.1_22 Being married and having a career is difficult. (22)	.541	.386
Q4.7_6 I didn't like technology. (6)[b]	.379	-.309
Q5.1_20 Racism is a bigger problem than gender discrimination. (20)[bc]	-.262	
Q7.4_1 Insufficient maternity leave (1)	.326	.636
Q4.6_2 Availability of bursaries (2)		.620

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	Difficulty to balance work and life	Personal discomfort
Q5.1_3 Women tend to have a lack of self-confidence. (3)		.615
Q5.1_28 It is difficult to resume a career after taking maternity leave. (28)	.362	.553

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalisation.[a]
a. Rotation converged in 3 iterations.
b. Remove item from factor score
c. Low communality

6.5.3.5 Principal Component Analysis 4 (PCA 4)

PCA 4 yielded the following indices:

a. Kaiser-Meyer-Olkin measure of sampling adequacy = .654, which was above 0.5, thus indicating distinct factors.
b. Bartlett's Test of sphericity approximate Chi-Square 305.641 (df = 66, p = .000), thus correlations were large enough for a PCA.
c. Determinant = .032 which indicated no multicollinearity between items.
d. Table 48 shows that 58% of commonalties were above point .6, while 33% were between .3 and .5, which were adequate for a PCA.

Table 48 Distribution of communalities PCA 4

Category	Frequency	Percentage
0	0	0.00
0.1	0	0.00
0.2	1	0.08
0.3	1	0.08
0.4	0	0.00
0.5	3	0.25
0.6	1	0.08
0.7	3	0.25
0.8	3	0.25
0.9	0	0.00
Total	12	100

The rotated component matrix and factor loadings for PCA 4 can be seen in Table 49. Three factors could be identified based on the scree-plot and one item was deleted from the eventual analysis. Factor 1 had 4 items, factor 2 had 3 items and factor 3 had 4 items. The three factors were:

a. Doubting own STEM-related ability
b. School context influence on STEM perceptions
c. Weak gender perceptions

Table 49 Rotated component matrix of PCA 4

	Doubting own STEM-related ability	Influence of school context on perceptions of STEM	Weak gender perceptions
Q4.5_5 Did you ever doubt your ability to do science? (5)	.827	.245	
Q4.5_6 Did you ever feel that you were not suited for a career in STEM? (6)	.802	.193	
Q4.5_4 Did you ever doubt your ability to do maths? (4)	.733	.346	
Q4.7_1 I doubted my ability to pass a STEM course. (1)	.611		-.179
Q4.5_1 Did primary school have a negative effect on your perceptions about science? (1)		.848	
Q4.5_2 Did high school have a negative effect on your perceptions about science? (2)	.196	.824	
Q4.5_7 To what extent are women's perceptions of STEM influenced by their teachers in a positive way? (7)	.195	.416	
Q4.3_1 Support of peers (1)[bc]		.278	-.125
Q6.2_4 Women should be less emotional. (4)		-.160	.802
Q6.2_3 Women should renounce their femininity. (3)	.232	-.214	.691
Q6.2_2 It depends on how hard women work. (2)	-.142		.666
Q6.2_5 Women should believe in themselves. (5)	-.229	.273	.597

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalisation.[a]
a. Rotation converged in five iterations.
b. Remove item from factor score.
c. Low communality

6.5.3.6 Description of factors

A total of 10 factors were identified from the four PCAs utilising groups of items. The purpose of reducing the 94 items to 10 latent variables was: first, to compare the STEM-status groups and second, to construct a model that could differentiate between the two STEM groups. In Table 26 the factors are labelled according to the content of the items and summarised along with a description of each factor. It is evident that the items of the EQ can be summarised by 10 variables, i.e., motivation; barriers and women's perceptions of their own abilities; the school context; and gender. Barriers can be broadly divided into obstacles experienced in society, in the workplace and in education, and personal barriers. Motivation can be divided into motivation found in external relationships and motivation found in relationships with close family members.

Table 50 Component labels and description

Component	Label	Description
PCA1_1	Motivation external	External relationships/persons motivating to embark on STEM career
PCA1_2	Motivation internal	Significant relationships motivating to embark on STEM career
PCA2_1	Barriers external	Cultural barriers in society and the workplace
PCA2_2	Barriers organisation	Barriers created by formal organisational structures
PCA2_3	Barriers education	Barriers in education, such as gender and racial discrimination
PCA3_1	Barriers balance	Work-life balance difficulty
PCA3_2	Barriers personal	Personal discomfort
PCA4_1	Perceptions ability	Doubting own STEM-related ability
PCA4_2	Perceptions school	School context influence on perceptions of STEM
PCA4_3	Perceptions gender	Weak gender perceptions

Table 51 summarises the statistical properties of the factors described in Table 50. The factor scores were calculated by adding the scores of items so that each had a weight of 1, which was then divided by the number of items to preserve the 5-point scoring scale. These factor scores were used in the comparisons of the two STEM groups, as well as in the construction of the logistic regression model. The reliability estimates for each factor can also be seen in Table 51. It is clear that the reliability (Cronbach Alpha) is low for factor PCA3_2, adequate for PCA4_2 and PCA4_3, and good to excellent for the rest of the factors.

Table 51 Statistical properties and reliability estimates of factors

Component	Label	No.	Minimum	Maximum	Mean	Standard deviation	Skewness	Standard error	Kurtosis	Standard error	Cronbach Alpha	No. of items
PCA1_1	Motivation external	105	0.36	4.91	3.05	0.86	-0.44	0.24	-0.04	0.47	.88	11
PCA1_2	Motivation internal	105	1.09	5.00	3.37	0.82	-0.34	0.24	0.14	0.47	.83	11
PCA2_1	Barriers external	104	0.05	4.26	2.57	0.84	-0.62	0.24	0.77	0.47	.94	19
PCA2_2	Barriers organisation	101	1.29	4.00	2.64	0.61	-0.25	0.24	-0.36	0.48	.87	13
PCA2_3	Barriers education	104	0.67	3.92	2.19	0.71	0.38	0.24	-0.16	0.47	.85	12
PCA3_1	Barriers Balance	104	0.13	4.75	3.01	0.84	-1.04	0.24	2.26	0.47	.88	11
PCA3_2	Barriers personal	104	0.25	5.00	3.07	0.85	-0.58	0.24	0.96	0.47	.57	4
PCA4_1	Perceptions ability	104	1.00	5.00	2.13	0.88	0.62	0.24	0.06	0.47	.79	4
PCA4_2	Perceptions school	104	0.67	5.00	2.24	0.77	1.22	0.24	2.52	0.47	.64	3
PCA4_3	Perceptions gender	100	1.25	5.00	2.94	0.70	0.64	0.24	0.79	0.48	.64	4

6.5.4 Inferential statistics: Factor differences between STEM-status groups

Table 52 indicates the factor scores for each of the two STEM groups. The STEM status groups were compared on each factor for significant differences in the mean score. The last three columns provide the details for the independent sample t-test. The significance values are two-way, which means that the last factor (or construct) showed a significant difference (*p* = 0.03). Thus, for perceptions about gender the non-STEM group scored significantly lower.

Table 52 Factor scores for STEM-status groups

Code	Factor label	STEM status										
		STEM				Non-STEM				t-value	Df	p
		N	Mean	SD	Standard error mean	N	Mean	SD	Standard error mean			
PCA1_1	Motivation external	86	3.09	0.85	0.09	19	2.87	0.94	0.22	1.00	103	0.32
PCA1_2	Motivation internal	86	3.41	0.83	0.09	19	3.19	0.77	0.18	0.28	102	0.78
PCA2_1	Barriers external	85	2.60	0.82	0.09	19	2.41	0.92	0.21	1.07	103	0.29
PCA2_2	Barriers organisation	83	2.63	0.59	0.07	18	2.66	0.72	0.17	0.91	102	0.36
PCA2_3	Barriers education	85	2.20	0.72	0.08	19	2.16	0.68	0.16	-0.16	99	0.87
PCA3_1	Barriers balance	85	3.03	0.81	0.09	19	2.91	1.00	0.23	0.18	102	0.86
PCA3_2	Barriers personal	85	3.11	0.79	0.09	19	2.88	1.11	0.25	0.59	102	0.56
PCA4_1	Perceptions ability	85	2.16	0.85	0.09	19	2.03	0.99	0.23	22.24	0.407	0.23
PCA4_3	Perceptions school	82	3.00	0.72	0.08	18	2.67	0.50	0.12	0.59	102	0.55
PCA4_2	Perceptions gender	85	2.25	0.79	0.09	19	2.19	0.69	0.16	1.88	98	0.06

In order to confirm the robustness of the difference between the two groups, a bootstrap for an independent t-test was done and reported on in Table 53. All except one of the confidence intervals ranged from minus to positive and confirmed the non-significant results of the t-test. One construct, namely, Perceptions Ability, had a positive confidence interval, but the lower value of 0 confirmed non-significance. The bootstrap confirmed the finding that there were no significant differences between STEM-status groups for the factor scores.

Table 53 Bootstrap for independent groups for factor constructs

Construct	Mean difference	Bootstrap[a]				
		Bias	Standard error	Sig. (2-tailed)	BCa 95% Confidence interval	
					Lower	Upper
Motivation external	0.28	-0.01	0.20	0.16	-0.13	0.65
Motivation internal	0.14	0.00	0.19	0.45	-0.26	0.52
Barriers external	-0.02	-0.01	0.18		-0.32	0.28
Barriers organisation	0.02	0.00	0.17	0.91	-0.33	0.36
Barriers education	0.04	0.01	0.19	0.83	-0.33	0.44
Barriers balance	0.19	0.01	0.25		-0.35	0.70
Barriers personal	0.09	0.01	0.25	0.72	-0.40	0.63
Perceptions ability	0.34	0.00	0.14		0.06	0.61
Perceptions school	0.03	0.00	0.18		-0.34	0.41
Perceptions gender	0.25	-0.02	0.25	0.30	-0.25	0.70
a. Sampling method: Simple; number of Samples: 1000; confidence interval level: 95.0%; confidence interval type: bias-corrected and accelerated (BCa)						

A comparison of the two groups did not indicate any factor that could substantially differentiate between the two groups. Based on these results and the non-significance of differences on the self-efficacy scales discussed in paragraph 6.4.2 above, one would not expect a successful construction of a logistic regression model.

6.6 Modelling: Logistic regression

Based on the above results (see Table 53), it was not expected that any of the factors or constructs would contribute in any way to making a distinction between the two STEM-status groups. A logistic regression was done, with all the constructs entered as independent variables. As expected, the model was not significant and could not distinguish in any way between the groups. The Omnibus test of model coefficients yielded the following: $\chi^2(13) = 10.79$, $p = .63$. The classification matrix (Table 54) confirms that the non-STEM group could just as well have been part of the STEM group.

Table 54 Classification table: STEM status

		STEM status		
		Yes	No.	Percentage correct
Set status	Yes	80	1	98.8
	No	18	0	.0
	Overall percentage			80.8

The performance of the independent variables can be seen in Table 55. Only gender perceptions were significant, but the inclusion of only this variable in the model yielded no improvement and a non-significant model.

Table 55 Logistic regression model[a] for STEM status

	B	S.E.	Wald	df	Sig.	Exp(B)
Occupational SE Scale	-0.03	0.07	0.15	1.00	0.70	0.98
New General SE Scale	-0.11	0.10	1.06	1.00	0.30	0.90
General SE Scale	0.09	0.11	0.63	1.00	0.43	1.09
Motivation external	-0.16	0.44	0.13	1.00	0.72	0.86
Motivation internal	-0.27	0.50	0.29	1.00	0.59	0.77
Barriers external	-1.01	0.74	1.83	1.00	0.18	0.37
Barriers organisation	1.07	0.81	1.74	1.00	0.19	2.92
Barriers education	0.56	0.62	0.82	1.00	0.36	1.75
Barriers balance	0.12	0.46	0.07	1.00	0.79	1.13
Barriers personal	-0.58	0.49	1.41	1.00	0.24	0.56
Perceptions ability	-0.45	0.42	1.15	1.00	0.28	0.64
Perceptions school	0.17	0.47	0.13	1.00	0.72	1.19
Perceptions gender	-1.10	0.54	4.12	1.00	0.04	0.33
Constant	6.39	4.44	2.07	1.00	0.15	593.28

[a]-2 Log likelihood = 83.09, Cox & Snell R Square = .10, Nagelkerke R Square = .179

6.7 Discussion

The total sample consisted of 108 respondents of whom 20 were in the non-STEM group and 88 in the STEM group. The unbalanced and non-random nature of the sample selection was taken into account during the investigation of variables, distributions and analyses.

A large number of the respondents had honours degrees and higher qualifications. The majority (67%) were English speaking, while the rest spoke either Afrikaans or an African language.

While a high percentage of the non-STEM women were married, the STEM group included more single women. Most of the respondents were employed. Although those in the STEM group worked in the STEM field, some were employed in management. The STEM participants who were students were mostly studying towards master's degrees, but included a few honours students. A large number of relatively experienced women had been in their current positions for 0–3 years, which implied that some job or position movement had taken place. In contrast, the non-STEM group showed a fairly even distribution for all the age groups for the category 0–3 years in current position.

The OSES and GSES had higher reliability coefficients than the NGSES. The GSES showed a high correlation with the OSES and the NGSES, which correlated somewhat with each other.

The GSES subsumed the other two. The STEM-status groups displayed very high levels of self-efficacy and there were no significant differences between the two STEM groups.

In both groups a personal interest and fascination with science played a prominent role in their decision to embark on STEM studies. Parents and teachers at school had also strongly influenced their choice of science as a field of study. Other role models did not really play an important role in their decisions and motivation.

The STEM group made it very clear that they remained in the field because they enjoyed their work and were happy in their work situations. Unfortunately, the same questions (Figure 22) were not posed to the non-STEM group and this aspect could be further explored in future studies. Women who had left STEM should be asked whether they enjoyed their work as their responses might actually reveal why they had left the STEM field. However, the trends between the two groups were so similar that this is unlikely.

The school educational context had been experienced positively by both groups with regard to their exposure to STEM. Tertiary training was also not regarded as having been too difficult in terms of the barriers experienced.

The groups had different views about women's self-confidence. The non-STEM group did not regard it as a barrier, while the STEM group did. This is very telling as one would expect their views to be the other way around as those who are in STEM should regard themselves as confident.

Both groups had strong feelings about combining family life, marriage, having children and raising children with a career and balancing family and work. Some work-related barriers such as discrimination were not really regarded as problematic.

Both groups felt that barriers can be overcome. Both groups also felt very strongly that women should believe in themselves. It is interesting to note that neither group had a problem with femininity and emotionality.

Both groups experience support from various people, but felt strongly about the value of support from mainly their partners, but also from their parents.

Both groups felt that women are not allowed sufficient maternity leave, lack opportunities for promotion and experience salary disparities.

An exploratory principle component analysis for groups of items was done. Indicators for the sufficiency of doing a factor analysis were taken into account. Ten components, factors or constructs were identified. The reason for doing the PCAs was to group items with high correlations together and investigate their content. All factors made psychological sense in terms of the items that were grouped together and the factors were labelled accordingly. The three broad categories of constructs were barriers, motivational factors and perceptions. The reliability of constructs was fairly adequate to high, which showed some internal consistency and supported the labels given to the constructs. The constructs were compared between groups and only one showed an almost significant difference. However, a bootstrap confirmed the non-significance of mean differences. A logistic regression confirmed that none of the constructs and the self-efficacy scales could separate the groups in any way. Overall one must assume that the characteristics measured were very similar in the two groups, and that one can only make some provisional observations based on visual inspection.

6.8 Conclusion

The statistical analysis showed that no real differences could be found between the STEM and non-STEM groups. Slight tendencies might yield some clues about the women's views of barriers and perceptions. The groups scored high on the self-efficacy scales and showed high levels of self-efficacy in general, but also in their occupations. The Exploratory Questionnaire (EQ) was reduced to 10 factors describing women's perceptions of the STEM field. It is important to make an observation about the lack of differences between STEM women and non-STEM women on the self-efficacy scales. One would expect the non-STEM group to show lower levels of self-efficacy than the STEM group for STEM careers. However, the non-STEM women probably did not rate themselves on their previous STEM careers when they completed the self-efficacy scales. It is most likely that they responded to the questions with their current careers in mind. It is therefore not surprising that they scored high on all three self-efficacy scales. It is possible that these women might regard themselves as not self-efficacious in the STEM field. However, they have high levels of self-efficacy in their current careers and positions where they experience fulfilment and success.

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CHAPTER 7

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

7.1 Introduction

This chapter focuses on a discussion of the empirical data, the conclusion based on the findings of the study and the researcher's recommendations. Following an indication of whether the research aims and the objectives of the study have been achieved, the way in which the research question was addressed is also discussed. The question focused on the role of self-efficacy in women's decisions to remain in or leave their STEM careers.

This question was investigated from a social-cognitive perspective and a mixed-methods approach was applied. The Social Cognitive Theory (SCT), as an explanatory framework, and mixed-methods, as the methodological approach, were used in an attempt to determine whether self-efficacy was necessary and/or sufficient for success in a STEM career, and how self-efficacy relates to factors preventing or enabling women's success.

The explanatory framework, namely Bandura's (1986) Social Cognitive Theory, views humans as active agents. The four characteristics of agency, namely intentionality, forethought, self-reactiveness and self-reflectiveness form the basis for self-efficacy (Bandura, 2006b, p. 164). To recall what was discussed in Chapter 3, intentionality captures the intention to act and the plan one puts in place for carrying out those intentions. Forethought includes the ability to direct one's actions to a goal on the grounds of the anticipated outcomes of future behaviour (Bandura, 1991, p. 248; 2006b, p. 164). Self-reactiveness stipulates that human beings can be proactive in order to realise their initial intentions (Bandura, 2006b, p. 165). Agency is encapsulated by human beings as *initiators of action,* but also as *self-regulators* (Bandura, 1991). Self-regulation flows from the ability to self-reflect and to thus monitor one's own actions (Bandura, 2006b, p. 165). Agency (or agentic capability) is the ability to act and self-regulate and forms the substrate of self-efficacy. As we know by now, self-efficacy is the belief that one is able to accomplish certain things (Bandura, 1995b, p. 2). This would not be possible if one had no ability or intention to act, or some form of self-reflectiveness to realise that one's abilities are efficacious.

The question of determining a person's sense of agency, i.e., a feeling of having some control over oneself and one's environment and not a sense of being a passive marionette delivered to circumstances and desires, is probably straightforward. One could ask people whether they are able to get out of bed, tie their shoelaces, feed themselves, work, reach goals and ideals, and so on. Thus, in essence, their levels of self-efficacy are applicable to specific domains, but also to general functioning, which would indicate the level of agency a person exhibits.

Bandura (2006b, p. 171) also states that self-efficacy beliefs influence outcome expectancies. In other words, what people believe they can do determines what they believe the outcome of certain actions will be. As discussed in Chapter 3, the converse might also be true, namely that outcome expectancies influence self-efficacy. As mentioned above, the concepts of self-efficacy and outcome expectancies play a crucial role in social cognitive career theory (SCCT) (Lent et al., 1996). Bandura's work influenced the domain of career choice and development to such an extent that it is currently an influential model of career behaviour.

However, self-efficacy and outcome expectations never operate in a vacuum. Bandura's (1986, 1999b) triadic model of psychological functioning comprising behavioural, intrapersonal and environmental determinants of behaviour further indicates that behaviour is not wholly individualistic and singly internally subjective. The reciprocal influence of each of the three determinants is important for agency because interaction with the environment, others and oneself provides the required information on whether one can control and change oneself and the environment. An individual is not a free-floating agent, but an agent situated in a real and socially active environment (Bandura, 1995b, p. 34).

It is against the background of SCT and the development of SCCT that this study investigated the role of self-efficacy in the staying power of women in STEM fields. Over the past 30 years, SCCT has developed into a dynamic theory capable of accounting for a number of relationships between explanatory variables and career outcomes. The sources of self-efficacy, decision making, career choice, persistence, career and study satisfaction and a number of related aspects all contribute to explaining or determining women's ability to remain in or leave STEM fields and careers. This study attempted to explore at least the role of self-efficacy, along with related aspects, in two samples, namely a smaller group of women with whom in-depth interviews were conducted and a larger sample who completed a survey. The findings of these two processes are compared in this chapter.

7.2 Research question, research aim and objectives

7.2.1 Research question

As previously stated, the research question of the study was:

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What is the role of self-efficacy in the different career trajectories of (a) women who stayed in the STEM field for at least three years; and (b) women who trained for STEM careers but who chose not to follow those careers, or decided to leave the field for some or other reason?

7.2.2 Research aim

The main aim of this study was to explore the role of self-efficacy in the career trajectories of women who studied in the field of STEM, some of whom pursued and remained in careers in STEM, and some who left this field. The argument was that differences in their experiences of self-efficacy could explain why women stay in or leave STEM.

7.2.3 Research objectives

To fulfil the aim of the research, the following objectives were formulated:

a. To examine the role of self-efficacy in women who have remained in STEM careers for at least three years.
b. To investigate the role of self-efficacy in women who studied in the STEM fields, but left their fields or made major career changes within the first three years after they had completed their studies.
c. To determine whether, with regard to self-efficacy, women who have established careers in STEM differ significantly from those who made career changes.

7.2.4 Research approach

A mixed-method approach, and specifically a parallel convergent design, was followed. The qualitative interviews included eight women who were working in STEM fields and seven women from the non-STEM group. The two groups were compared to investigate the assumption that self-efficacy is essential for a woman to be firmly established in a career in STEM. This implied that women with high self-efficacy might stay in STEM careers. It also suggested that a lack self-efficacy in the STEM field could predict failure in this particular field. Furthermore, it might also mean that women who changed their career paths due to a lack of self-efficacy in STEM might experience high levels of self-efficacy in their new careers. The first of the two groups in the purposive sample included women who had worked in STEM for at least three years and the second group included those who had studied in the STEM field, but changed to different careers.

The electronic survey was made available via a web survey tool. The total sample of 108 women consisted of with 20 in the non-STEM group and 88 in the STEM group. The STEM status variable was used to explore the differences in sample characteristics, biographical information, self-efficacy scale results and STEM-related exploratory aspects (by means of the Exploratory Questionnaire or EQ used in this study).

7.3 Discussion of research results

The data was obtained from participants through a purposive sample strategy. In each of the quantitative and qualitative groups, two groups of women were identified –one group that was still working in the STEM field and another group that consisted of women who had studied in the stem field, but had left it. In the qualitative group, a total of eight interviews were conducted with the STEM group and seven with the non-STEM group. In the quantitative group a total sample of 108 women responded, of whom 20 were in the non-STEM group.

7.3.1 Comparison of samples

In the qualitative group the average age for the STEM group was 42.38 years (SD = 16.01), with their ages ranging between 30 and 78 years. The average age for the non-STEM group was 44.83 years (SD = 2.64) with the youngest 41 and the oldest 48 years of age. The participants' fields of specialisation were engineering (chemical, civil, electrical and electronic, and mechanical engineering), science (agriculture, geography, geology, ionospheric physics, nuclear physics, mathematics, quantitative genetics, applied mathematics, *o*perations research and statistics).

The ages of the respondents in the quantitative group ranged between 23 and 65 years and the average age was 39.86 years. The STEM group had a mean age of 39.28 years (SD = 10.55), with the youngest 24 and the oldest 64 years of age. The non-STEM group's mean age was 42.40 (SD = 12.00), with the youngest 23 and the oldest 65 years of age. Table 56 shows the mean ages for all the groups and the results of independent sample tests carried out between categories. The groups were compared for significant differences in age. A Mann-Whitney test was done to compare the STEM and non-STEM groups for the qualitative sample. Footnote a. in Table 56 provides the statistics for this comparison. A t-test was done to compare the STEM and non-STEM groups for the quantitative sample and footnote b. in Table 56 provides the detail of the test. Finally, the grand totals for the qualitative and quantitative samples were compared and footnote c. in Table 56 provides the statistics. One can assume that the quantitative and qualitative groups did not differ significantly in terms of mean age (t = -1.15, df = 120, p = .254 two-tailed).

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Table 56 Sample means: age

	Qualitative[c] (n = 14) Mean (SD)			Quantitative (n = 108)		
	STEM[a]	**Non-STEM**	**Total**	**STEM[b]**	**Non-STEM**	**Total**
Age	42.38 (16.01)	44.83 (2.64)	43.43 (11.93)	39.28 (10.55)	42.40 (12.00)	39.86 (10.84)

a. Mann-Whitney U = 32.5, p = .282 (two-tailed)

b. t = -1.162 df = 106, p = .248 (two-tailed)

c. t = -1.15, df = 120, p = .254 (two-tailed)

In the qualitative STEM group, 63% of the participants were White and 37% were Black. The non-STEM group consisted of two Black and five White women (see Table 57).

Race was not explicitly included in the quantitative survey, but participants were requested to indicate the language they spoke. The STEM group included 61 English-speaking women (which could have been a mix of Black and White participants), 10 who spoke African languages, and 14 Afrikaans speakers (which could have been a mix of White and Coloured women). The remaining three participants indicated other languages. The non-STEM group consisted of 11 English-speaking women, three who spoke African languages and six Afrikaans speakers. The English and Afrikaans speakers were added together to estimate the number of White participants (see Table 57).

Table 57 Sample comparison: race

	Qualitative				Quantitative		
	STEM[a]	**Non-STEM**	**Total**		**STEM**	**Non-STEM**	**Total**
Black	3	2	5		10	3	13
White	5	5	10		75	17	92

a. Qualitative sample race x STEM-status: $\chi^2(1)$ = 0.13, p = 1.00 (Fisher's Exact Test)

b. Quantitative sample race x STEM-status: $\chi^2(1)$ = 1.56, p = .710 (Fisher's Exact Test)

c. Both samples race x Qual/Quant group: $\chi^2(1)$ = 4.52, p = .049 (Fisher's Exact Test)

Three Pearson Chi squares were calculated for 2 x 2 tables: a) the qualitative sample for race x STEM-status; b) the quantitative sample for race x STEM-status; and c) both samples combined for race x method (qualitative/quantitative). For small expected cell frequencies less than 5, Fisher's Exact Test was reported for the significance value for the Chi Square (Sheskin, 2004). The Chi square indicated that there was no relationship between race and STEM status

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for the qualitative and quantitative samples (see notes a. and b. in Table 57). A significant relationship between race and research approach was evident when both samples were combined in a 2 x 2 table. The cells indicate that there were many White participants in the quantitative sample (n = 92) and very few Black participants in the qualitative sample (n = 5). The two samples were thus not equal in terms of race.

In the qualitative STEM group, five participants were married, while six in the non-STEM group were married. Three women in the qualitative STEM group, and only one in the non-STEM group, were single. The quantitative STEM group included 59 married women, while 15 in the non-STEM group were married. Twenty-nine women in the quantitative STEM group, and only five in the non-STEM group were single. In both groups the single non-STEM participants were in the minority (Table 58).

Table 58 Sample comparison: relationship status

	Qualitative				Quantitative		
	STEM	Non-STEM	Total		STEM	Non-STEM	Total
Married	5	6	11		59	15	74
Single	3	1	4		29	5	34

a. Qualitative sample race x STEM-status: $\chi^2(1) = 1.03$, $p = .569$ (Fisher's Exact Test).

b. Quantitative sample race x STEM-status: $\chi^2(1) = 0.48$, $p = .489$.

c. Both samples race x Qual/Quant group: $\chi^2(1) = 0.14$, p = 1.00 (Fisher's Exact Test).

Table 58 shows that all three comparisons were non-significant, thus, with regard to marital status, there were no differences between the distributions of the groups.

In the qualitative group the women with the highest qualifications included participants with doctoral degrees in STEM, one of whom was a professor. Three had master's degrees and two had BSc degrees. In the non-STEM group, two participants had master's degrees, one had an honours degree and the rest had basic STEM degrees. As can be seen in Table 4, the quantitative group included one participant with a doctoral degree, 54 with master's, 36 with honours and 17 with bachelor's degrees. The participants with diplomas were in the non-STEM group which, it is interesting to note, also included the one person with a PhD. The majority of non-STEM participants had honours degrees and the majority of STEM participants had master's degrees.

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Table 59 shows the distribution of qualifications for both the qualitative and quantitative groups. Because of low cell counts, the categories for bachelor's and honours degrees were collapsed, as well as the category for a master's degree with a PhD. Comparisons were made for each of the samples for STEM status and highest qualification. It can be seen that there was no relationship between STEM status and qualifications for the qualitative sample. In the case of the quantitative sample there was a relationship, which indicated that the groups could not be regarded as similar. However, the qualitative sample and the quantitative sample did not differ with regard to the distribution of qualifications ($\chi^2(1)$ = .03, p = 1.00 Fisher's Exact Test).

Table 59 Sample comparison: qualifications

	Qualitative				**Quantitative**		
	STEM	**Non-STEM**	**Total**		**STEM**	**Non-STEM**	**Total**
B degree / Hons	2	5	7		38	15	53
M / PhD	6	2	8		50	5	55

a. Qualitative sample race x STEM status: $\chi^2(1)$ = 3.23, p = .132 (Fisher's Exact Test).

b. Quantitative sample race x STEM status: $\chi^2(1)$ = 6.60, p = .010.

c. Both samples race x Qual/Quant group: $\chi^2(1)$ = .03, p = 1.00 (Fisher's Exact Test).

In conclusion, the comparison between the qualitative and quantitative groups showed that they differed in terms of race distribution. The groups were similar in terms of qualifications, marital status and age.

7.3.2 Comparison between themes

In this section the themes found in the qualitative results and the factors found in the quantitative results are compared. This comparison facilitated a deeper understanding of a number of issues involved in keeping women in STEM, or issues that cause them to leave.

For the sake of easy reference, the themes identified in the qualitative sample are repeated in Table 61 below. The theme numbers and labels, their descriptions and descriptions of the subthemes are given. There were 12 themes and these are compared with the factors found in the quantitative sample. The qualitative themes are given on the left side of the table.

The factors found in the quantitative sample factor analysis are provided in Table 60. Again, for ease of reference, the original factor number used in Chapter 6 is provided along with the label and a description of the factors. The mean scores for the STEM and non-STEM groups are also provided. The scores, it should be remembered, range from 1 to 5, with the low scores

(1 and 2) indicating never and rarely, 3 indicating sometimes, and the high scores, 4 and 5, indicating frequently and always. For instance, a low score on the factor “Barriers balance” (PCA3_1) indicates that the respondent experienced infrequent difficulty with managing a balance between work and life. In the discussion below, the scores in this table are used to indicate trends.

Table 60 Mean scores for the factors of the quantitative sample

Component	Label	Description	Mean	
			STEM	Non-STEM
PCA1_1	Motivation external	Motivated by external relationships/persons to embark on STEM career	3.09	2.87
PCA1_2	Motivation internal	Motivated by significant relationships to embark on STEM career	3.41	3.19
PCA2_1	Barriers external	Cultural barriers in society and workplace	2.60	2.41
PCA2_2	Barriers organisation	Barriers created by formal organisational structures	2.63	2.66
PCA2_3	Barriers education	Education barriers, such as gender and racial discrimination	2.20	2.16
PCA3_1	Barriers balance	Work-life balance difficulty	3.03	2.91
PCA3_2	Barriers personal	Personal discomfort	3.11	2.88
PCA4_1	Perceptions ability	Doubting own STEM-related ability	2.16	2.03
PCA4_2	Perceptions school	School context influence on STEM perceptions	3.00	2.67
PCA4_3	Perceptions gender	Weak gender perceptions	2.25	2.19

There is some overlap between the themes and factors in terms of content. In some instances, one-to-one mapping was difficult and the researcher had to find different factors that addressed a particular theme. Table 61 provides the mapping of themes and factors along with additional information found in the quantitative results to facilitate a comparison. Some items from the EQ discussed in the previous chapter were also recruited to address themes, thus providing evidence for similar issues in both samples. The qualitative themes are listed on the left side of Table 4 and the quantitative themes, along with additional evidence, on the right side. Items from the EQ are indicated by using their numbers as indicated in Chapter 7. The self-efficacy scales are also utilised as evidence for certain themes and their scores, along with an indication of the scale names (NGSES, OSES and GSES). Factor PCA2_1 indicates an issue found in the quantitative analysis, but not in the qualitative section. This factor refers to external barriers and includes aspects such as hiring practices and office culture. However, similar issues are dealt with under the qualitative theme “Personal barriers” and will be discussed in that particular section. Outcome expectancies, as Theme 5 in the qualitative section, are not reflected in the quantitative part. No concrete evidence could be found for outcome expectancies in the quantitative results.

Table 61 Theme and factor comparison

Qualitative theme				Quantitative factors and items
Theme number	Theme	Description	Sub-theme	
1	Self-efficacy	The belief that one has the capability to do certain things	Judgement of own ability Reaching goals Willingness to do tasks	PCA4_1 Perceptions ability (2.16, 2.03) They do not doubt their abilities (low score almost 1 below midpoint. Stem course, maths, not suited for STEM, science. Q4.5_4 Did you ever doubt your ability to do maths? (4) Q4.5_5 Did you ever doubt your ability to do science? (5) Q4.7_1 I doubted my ability to pass a STEM course (1) Self-efficacy scales NGSES : Successful in setting goals, can overcome difficulties, can do many different tasks, resilient OSES: One question that deals with career, the rest of the questions deal with current job issues setting goals in job managing problems and difficulties feeling confident in job and with abilities achieving goals planning in occupational future GSES Focuses on coping self-efficacy i.e. abilities to meet demands, rely on abilities to problem solve, reach goals and deal with difficulties.
2	Agency	Intention, willingness and energy to act	Intentionality (intention to act) Self-reflectiveness (self-regulating)	Q4.5_6 Did you ever feel you were not suited for a career in STEM? (6) (2.10) Q6.2_5 Women should believe in themselves (5) (4.70)
3	Career decision making	Making choices with regard to study fields, which careers to follow and which jobs to choose	Academic performance Career choice Performance in career/job	OSES question "When I make plans concerning my occupational future, I can make them work."
4	Resilience	The ability to persevere in the face of obstacles	Recovery from disappointment or obstacle Persistence	Q5.1_18 Male discrimination just motivates me to work harder (18) (3.4) Q6.2_1 These barriers can be overcome (1) (3.88) Self-efficacy scales especially GSES
5	Outcomes expectancy	Expecting certain reactions from doing certain actions		
6	Family life		Motherhood Marriage Personal work-life balance	PCA3_1 Barriers balance (3.03, 2.91) Time for family, inflexible working hours, balancing work-life (3.57) children and work is difficult (4.16), married is difficult.
7	Work barriers	Obstacles experienced in the STEM work environment	Male-dominated environment Lack of promotion, acknowledgement, salary	PCA2_2 (2.63, 2,66) Barriers organisation – promotion, management, gender pay gap, poor salaries. Lack of career opportunities
8	Sources of self-efficacy		Mastery experiences (own attempts to control environment)	PCA4_1 Perceptions ability (2.16, 2.03) PCA4_3 Perceptions gender (2.25, 2.19) Women should not renounce femininity or be less emotional

Qualitative theme				Quantitative factors and items
Theme number	Theme	Description	Sub-theme	
			Vicarious experiences (seeing something done by someone else) Supportive experiences (verbal/social persuasion) Emotional experiences (physiological and emotional states that accompany actions)	Women should believe in themselves (4.7) Q4.2_1 I enjoy my work (4.28) Q4.2_4 My work has a beneficial impact on others (3.93) Q4.2_6 I enjoy working with colleagues (3.89) Q4.2_7 I enjoy developing my skills (4.45) Q4.2_8 I enjoy doing research (4.16) Q4.2_9 I enjoy doing practical things (4.20) Q4.2_10 I set high goals for myself (4.33)
9	Educational barriers	Both school / tertiary educational obstacles	Tertiary: Lecturers discouraged girls Tertiary: Negative classroom environment	PCA2_3 Barriers education (2.20, 2.16) Prejudice against women, negative from female students, male students, gender insensitive curricula, teachers prejudiced against women, educational system is male orientated, marginalisation as woman (most 2 and lower) PCA4_2 Perceptions school (3.00, 2.67) Negative influence of primary and secondary schools, teacher influence
10	Personal barriers	Obstacles and difficulties at home	Doubting own ability Family issues No support structure	PCA3_2 Barriers personal (3.11, 2.88) Maternity leave, bursaries, lack of self-confidence. Average scores PCA4_3 Perceptions gender (3.00, 2.67) Women should believe in themselves (high score) Have no problem with emotion and femininity PCA2_1 Barriers external (2.60, 2.41) Hiring practices; recruitment practices; office culture; limited opportunities for women; science is a male career; women not capable scientists. Very average scores
11	Motivation to embark on STEM studies/ career		Motivation and support by parents Personal interest Siblings Family Teachers Other external people	PCA1_1 Motivation external (3.09, .2.87) Colleagues, lecturers, teachers, role models, friends and manager PCA1_2 Motivation internal (3.41, 3.19) Own interest in science (attending exhibits, etc.), parents/parents interest in science, partner support
12	Leaving STEM	Any consideration to leave STEM	Not interesting any more Marriage and children Want to work with people	Q7.1_1 If you are currently in a STEM career, to what extent would you consider a change of career? (1) (2.17 – STEM) Q7.1_2 If you are NOT currently in a STEM career, to what extent would you like to return to a STEM career? (2) (3.6 – non-STEM)

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7.3.2.1 Theme 1: Self-efficacy

Bandura (1995b, p. 2) describes self-efficacy as "beliefs in one's capabilities to organize and execute the courses of action required to manage prospective situations." According to Bandura (1986, p. 391), self-efficacy is a better determinant of performance than basic skills. The discussion of the data will focus on the qualitative data first, and then on the quantitative data.

a) Qualitative group

Eight women who were still actively working in the STEM field (including one retiree who was still working part time) were interviewed. From the discussion of their career trajectories with women in the STEM-field, all the women clearly showed high self-efficacy and were focused on achieving their career goals in their respective fields. These women were also very confident about their abilities. They made remarks such as *"… did do good work. Really, there is no doubt in anybody's mind that the work I did was good*'', "*I never doubt my capabilities*", and *"… but I thought I would have a competitive edge, being one of a few.*"

This group was also willing to do whatever was required to reach their goals. They often mentioned the difficulties experienced in their career paths, but were willing to "stick around", "to take the difficult road" and commit to the "purpose" of their lives (see the discussion in Chapter 5).

The seven women in the non-STEM group experienced similar difficulties in their careers, but decided to leave the field because of "the negative responses from the industry [for a female]. One mentioned that she "*felt incompetent after having been 'only' a mother for a few years*." Another participant said*: "I suppose I wasn't successful, if you take into account my working history.*" It is interesting to note that even though not one of the seven women in the non-STEM group showed career self-efficacy while they were in their STEM fields, they all showed self-efficacy in their "new" careers. One participant said: *"[A science career] it's helped me, to advance to where I am, I am right, now*!" Several other participants emphasised their satisfaction with their "new careers" (see Chapter 5).

b) Quantitative group

In the quantitative group, the means of the self-efficacy scales were close to each other and there was no significant difference between the groups. Against expectations, the self-efficacy levels of the non-STEM group were very similar to those of the STEM group. This caused the researcher to speculate that the non-STEM group might have evaluated their job performance against their current (new) careers. Although the survey made provision for STEM and non-STEM respondents by splitting sections depending on their STEM status, the non-STEM group probably answered the survey from their current career perspective and not their STEM perspective.

As seen in Chapter 6, the New Generalised Self-Efficacy Scale (NGSES) performed slightly better than the OSES and the GSES when the reliability estimates are considered. The NGSES also subsumed the latter two when looking at the correlations between the three scales (see Chapter 6). The NGSES covered issues related to self-efficacy, such as believing that one can achieve goals, overcome difficulties and perform many different tasks, and a belief in one's own resilience. Self-efficacy is applicable to a variety of situations and tasks and the questionnaire did not focus on one specific segment of behaviour. From their high scores on the NGSES it is apparent that both groups of women believed that they had high levels of generalised self-efficacy. However, generalised self-efficacy does not imply STEM self-efficacy (Maree & Maree, 2013, p. 452).

The Occupational Self-Efficacy Scale (OSES) focuses mainly on experiences within one's current job. It contains only one question that deals with a person's career in general (the belief that one has the ability to plan one's career), and the rest of the questions deal with current job issues, such as:

a. Setting career goals
b. Managing problems and difficulties in one's job
c. Feeling confident in a job and with one's ability to do the job
d. Regarding oneself to be able to meet goals

Both groups scored high on the OSES, which means that they both regarded themselves as self-efficacious in their current jobs (Rooney & Osipow, 1992).

The focus of the General Self-Efficacy Scale (GSES) differs slightly from that of the NGSES and when looking at the content of the items it is understandable that it was revised. The GSES content focuses on coping self-efficacy and includes items dealing with one's belief that one can cope, for instance with difficulties and complicated situations. It also deals with relying on one's ability to meet demands, solve problems, achieve goals and deal with difficulties. It deals with issues that are similar to those in the NGSES, but contains more items that relate to the ability to cope with obstacles. Both groups scored high on this test, which showed that they believed that they could cope in a variety of circumstances. This test is also applicable to the theme of resilience discussed below (Chen et al., 2001).

On Factor PCA4_1 or Perceptions about women's ability, the STEM and non-STEM groups had means of 2.16 and 2.03 respectively (Table 60). The low score means that they answered "never" or "almost never" to questions incorporated in the factor. They did not doubt their abilities and also did not doubt that they could achieve success in STEM courses, mathematics and science, i.e., they were confident that they were suited for STEM. This observation applies to both the STEM and non-STEM groups.

As mentioned in paragraph 7.3.2.1 on page 270, it was surprising that the self-efficacy scores in the quantitative study were high for both groups with only a minor difference, whereas in the qualitative study a clear difference was seen in self-efficacy of the two groups. The women who had remained in the STEM field showed remarkably high levels of self-efficacy compared to those in the non-STEM group. The assumption is that the women in the non-STEM group completed the quantitative questionnaire with their current careers in mind. Even though the questionnaire stipulated that the non-STEM group should complete a different part of the questionnaire in which they were asked about their career experiences, they might have interpreted the questions as referring to their current careers.

c) Theme 1 conclusion

From the qualitative results, it was clear that self-efficacy played a distinctive and crucial role in the careers of women who are currently employed in STEM fields. It seems as if non-STEM women had not experienced high levels of self-efficacy while working in their STEM fields, but did experience high levels of self-efficacy in their subsequent non-STEM careers. From the quantitative study, it is clear that both STEM and non-STEM women who had started off in STEM experienced high self-efficacy as there was no difference between the two groups with regard to their self-efficacy and both scored very high.

7.3.2.2 Theme 2: Agency

As mentioned in the overview in paragraph 7.1, agency captures a person's ability and willingness to engage and act within the environment and context. One may regard agency as the opposite of passiveness or inability to control oneself and one's environment. Agency therefore is the source of what is required for someone to exhibit self-efficacy. It is possible that people who are passive and have a low sense of agency will also have low levels of self-efficacy (Bandura, 2006b). A person with agency is someone who acts intentionally (intentionality) and plans to achieve goals (both forethought and goal directness).

a) Qualitative group

The qualitative group of STEM participants, without exception, showed very high levels of agency (Bandura, 1995b, p. 25). All the respondents could relate situations in which they experienced difficulties/obstacles, but they always saw them as challenges or opportunities to do things differently. In Chapter 5 (see 5.7.2) the example of Participant B was highlighted. Owing to her dyslexia, she had initially been in a remedial class, but worked so hard that she was transferred to a mainstream class and was soon one of the top students. She related: "*So, I feel like I find my space okay, and if I haven't, it is not because I doubt myself because I am a woman. I never doubt my capabilities."* She displayed agency and a willingness to work extra hard to achieve her goals. Another participant shared the problems she faced when she worked in an all-male team that excluded her from projects. Even though she was emotionally hurt, she took up the challenge and dealt with the situation.

In contrast with the STEM group, several participants in the non-STEM group showed no or very little agency with regard to their STEM careers – a finding supported by Hackett (1995, p. 234). Several participants in this group mentioned that they could not continue in the STEM field because it made no provision for the demands of motherhood and family life. This was in contrast with the women in STEM group, who created ways to deal with this issue.

b) Quantitative group

From the quantitative results, it was clear that the problem of having to balance career and family life was one of the most important barriers for both the STEM and the non-STEM groups. The fact that the STEM group experienced it as a huge problem, but still continued to work in the field is an indication of both agency and self-efficacy. The non-STEM group showed a similar inclination, but it is possible that they answered the question from the perspective of their current jobs. This was followed, in order of importance, by questions relating to the barrier of experiencing difficulty in balancing career and personal life. In answering one of the questions that followed, both groups indicated that barriers can be overcome when women believe in themselves. The STEM group also indicated that success in this regard will depend on how hard you work. Again, this is an indication of both agency and self-efficacy.

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Questions Q4.5_6 and Q6.2_5 applied to agency. The former, *"Did you ever feel you were not suited for a career in STEM?"* produced a mean score of 2.10, which means that the women in the group almost invariable answered negatively, which means that they all felt that they were suited for a STEM degree.

A mean score of 4.70 was calculated for the second question, Q6.2_5: "*Women should believe in themselves.*" This is very high and close to 5, or a full positive answer ("Yes always"). The respondents strongly believed that women should believe in their abilities, which means that women should have and exhibit agency or the impetus to achieve things.

It was once again surprising (see paragraph 7.4) to note that the quantitative data did not show a significant difference in the agency of the participants, while a clear difference was noticeable in the qualitative group. The one question in the EQ, Q4.5_6, applies to agency: *"Did you ever feel you were not suited for a career in STEM?"* The mean score for the sample was 2.10 for this question, which meant that both groups felt that they were suited for a STEM career (even the non-STEM group!).

c) Theme 2 conclusion

The information obtained from the qualitative group was very clear about women's levels of agency. The STEM group provided evidence of perseverance in the face of obstacles and controlling their environments. They appeared to exhibit agency to a greater extent than the non-STEM group. The distinction between the STEM and non-STEM groups was not that apparent in the quantitative sample. To some extent there is evidence that both groups show agency and willingness to be proactive and goal oriented, and to initiate action.

7.3.2.3 Theme 3: Career choice

The ability to orientate one's studies by making appropriate career choices is an indication of career maturity. The ability to complete studies is also an indication of determination to remain in a particular field, but as the research discussed in Chapter 3 showed, other factors, such as appropriate career choices and the ability to make good decisions, also play a role. It seems as if the enjoyment of studies and one's work is important, i.e., the satisfaction derived from the results of one's choices and decisions are even more important and are indicative of the likelihood that a person will remain in a particular field.

a) Qualitative group

Most of the participants in the STEM group showed commitment and were content in their careers. They shared several stories as examples of the career satisfaction they experienced. Their satisfaction was evident from comments such as the following: "*I'm going to specialise in it forever"; "I looked for a career that focused on my strong points"; "I enjoy the technical side of things, I enjoy figuring out how to approach a problem*," and "*my job is satisfying*" and "*encouraging*."

Most of the participants in the non-STEM group did not show strong career self-efficacy for their STEM careers. They referred to their initial STEM careers as "not successful" and made comments such as: "*I had no intention of returning*"; "*Science [career] is not practical, ... the workplace is not built around women*" and "*Wow, this is really a guy's environment*." Even though the non-STEM participants did not show career self-efficacy in their STEM professions, several did show self-efficacy in their subsequent careers.

b) Quantitative group

The survey did not include a question that covered aspects of career decision making per se, except for the one question in the OSES which read: "*When I make plans concerning my occupational future, I can make them work.*" This question expresses expectations similar to outcome expectations, i.e., if one does x, then y can be expected. Both groups scored high on this question, which again confirmed the suspicion that non-STEM women completed the survey from their current vantage points.

c) Theme 3 conclusion

The results of the qualitative survey clearly showed that the STEM group appreciated their careers and enjoyed aspects such problem-solving and work that posed a challenge. It was obvious that they were satisfied with the choices they had made regarding both their studies and their careers. The fact that the non-STEM group had left the STEM field and gave different reasons for their choices indicates a poor fit between what they studied and the kind of career environments in which they would have been happy.

7.3.2.4 Theme 4: Resilience

Resilience is the ability to overcome difficulties and misfortune. Resilience is an integral part of self-efficacy and individuals with high levels of self-efficacy and agency tend to persevere in the face of obstacles.

a) Qualitative group

All the participants in the STEM group showed resilience. Numerous examples of resilience were quoted in Chapter 5. The members of this group showed their commitment to their studies and work by relating experiences such as *"sleepless nights"* while doing experiments. One respondent said: "*I would rather take the stumbling blocks and maybe somewhere come out at top and be able to build a bit more of a career*" and "*I have learned the hard way … and this is where I am going to stay*."

The non-STEM group did not show much resilience in their STEM careers, but in several instances showed resilience in their "new" careers. Some examples of the absence of resilience were: One has to "give something up" when one decides to stay in a STEM career; "I believe that there won't be any other career for me" and "children are always a problem when it comes to a woman and her career."

b) Quantitative group

To a large extent the GSES, as discussed above, expressed *coping* self-efficacy and resilience. Both groups were very confident about their own coping abilities. Two questions in the EQ dealt with resilience, namely:

a. (Q5.1_18) Male discrimination just motivates me to work harder (M = 3.4)
b. (Q6.2_1) These barriers can be overcome (M = 3.88)

The responses to the first question expressed a slight tenacity to work harder when discrimination is encountered, while the responses to the second indicated a strong belief from the sample about the possibility of overcoming barriers. It seems as if even the non-STEM group believed that barriers and obstacles in STEM can be overcome. This is interesting because they were the ones who had left and had stated the main reason for their exit from the STEM as the problems experiencing when trying to find a balance between work and family life, as discussed below.

c) Theme 4 conclusion

In the qualitative results, it was clear that the STEM group showed high levels of resilience. The non-STEM group did not show similar levels of resilience in their STEM careers, but it was evident that in their new careers some did show high levels of resilience. The quantitative results confirmed both groups' resilience. This conclusion for the quantitative sample was somewhat confusing since, despite their indication of resilience, they were the women who had left their careers.

7.3.2.5 Theme 5: Outcome expectancy

Outcome expectancy beliefs refer to behaviour that will produce a certain outcome. In Chapter 3 we saw that Bandura and other researchers agree that outcome expectations along with self-efficacy play a role in successful results and performance.

a) Qualitative group

The STEM group shared several incidents illustrating outcome expectancy. An excellent example was discussed in Chapter 5, where Participant B referred to the opportunity to study further:

> *Oh, there is this opportunity and I am going to work really hard at it to see. So, it is really like taking opportunities and working very hard at it. Because then people are like 'You got your PhD in Physics, you must be so clever', and most of the time I am like 'No, I just worked hard.'*

Another example quoted in Chapter 5 is that of the participant who had to do a basic and an honours degree in order to be accepted into her preferred field of study.

The non-STEM group provided no examples of outcome expectancy in the stories they shared about their time in STEM careers.

b) Quantitative group

Except for the one abovementioned question in the OSES, no other questions dealt with outcome expectations.

c) Theme 5 conclusion

While the qualitative results for the STEM group produced several examples of outcome expectations, no such examples were provided by the non-STEM group. The quantitative study did not specify outcome expectations.

7.3.2.6 Theme 6: Family life

Family life is a crucial aspect in the career of any woman. Some women succeed in successfully combining family life with strenuous careers, while others might decide to rather focus on family and children. Some may struggle to find a balance between family and career but nevertheless persevere in their careers, but it is a fact that for women with families, family life and children will always present a challenge. Usually work-life balance is invariably mentioned as an obstacle, as was seen in Chapter 2. It is assumed that especially women in STEM careers might experience this as a serious obstacle to remaining in STEM.

a) Qualitative group

Family life was important to the participants in both the STEM and non-STEM groups. In the STEM group, family was often a motivating factor in the participants' career decisions. One of the participants in the STEM group shared her story about the impact of work on her family. She said:

> *Yes, at some stage [worked impacted on family life]. You see as a mother your kids want you home at a certain time. As I said there were times where I needed to be in the lab to complete this project, if it is a target it is difficult. It is not that I am afraid to fail, I think it is because I am ambitious, I am someone that wants to complete whatever I started.*

Another participant in the STEM group shared a similar story and said that her motivation to continue was the fact that she was a mother and she needed to take care of her family. This motivated her to excel in her career so that she could provide for the family.

Several of the participants in the non-STEM group were of the opinion that they could not manage a career in STEM while also fulfilling their roles in their families. One of them said: "*To me a family is, my family is very important and I wouldn't … encourage my daughter to study … in science because it's not, very, practical to have, uh, to combine family and science.*" It is interesting to note that these women did not find it difficult to combine family life with their current careers.

b) Quantitative group

Factor PCA3_1, which dealt with work-life balance, provided the quantitative group's perceptions about personal obstacles. The mean score for this factor was 3.03 for the STEM group and 2.91 for the non-STEM group which were both very close to the mid-point. This is interesting and means that there were no negative or positive feelings about dealing with the work-life balance. The questions included under this factor dealt with having time for family, inflexible working hours, and married life making it difficult to balance work and personal life.

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The factor included two questions about the problems experienced while trying to balance work and life (M = 3.57) and the difficulties of being a working mother (M = 4.16). From the scores obtained for the total sample indicate that the women regarded these two issues as problematic. However, the factor scores did not reflect this problem as the majority of items scored close to the midpoint. One can assume that these two issues were major problems for both groups, but that they dealt with it differently – some decided to leave STEM and others juggled work and children. However, as was seen in Chapter 2, family life and balancing work and life are usually mentioned as one of the barriers that has to be dealt with by professional women (Gnilka & Novakovic, 2017; Wang, Chan, Soffa, & Nachman, 2017).

c) Theme 6 conclusion

The qualitative discussion made it clear that both the STEM and non-STEM groups struggled with issues around family life. However, the women in the STEM group found ways to deal with family issues while those in the non-STEM group decided to leave the field in order to deal with the family issues. This does not mean that all the STEM women managed to solve their difficulties with balancing family, children and a career. One does get the impression that this remains a difficult and challenging issue (Cross, Linehan, & Murphy, 2017; Fouad, Singh, Cappaert, Chang, & Wan, 2016; Isaksson, Johansson, Lindroth, & Sverke, 2006; Kelly, 2016; Singh et al., 2013). The need to tolerate or deal with family challenges comes with STEM group's commitment and passion for their work. Again, this does not imply that the non-STEM women did not have a passion for their STEM fields, but it does seem as if they almost invariably mentioned family life as their reason for leaving their STEM careers. Note, however, that those who moved to other careers seemed to be able to successfully combine their current careers with family life.

The issue of balancing work and family life is one aspect that the qualitative and quantitative groups agreed on, especially if one examines the items dealing with these aspects. The quantitative results also showed that work-life balance and family life are difficult issues to deal with when working in the STEM field. Both STEM and non-STEM groups in the qualitative and quantitative groups found it challenging to balance work and life outside of their careers (Peña-Calvo, Inda-Caro, Rodríguez-Menéndez, & Fernández-García, 2016).

7.3.2.7 Theme 7: Work barriers

Work barriers refer to issues of discrimination in the workplace, among other things, as well as aspects as obvious as salary disparities and opportunities for promotion. This obstacle was also discussed in Chapter 2 and it is one of the prominent aspects always explored in studies concerned with women working in STEM fields.

a) Qualitative group

In both the STEM and non-STEM groups the participants concurred that there were many work barriers to deal with, such as the male-dominated environment, the distrust in the women's capabilities as professionals, poor provision for the needs of women with families and many more. The STEM group participants generally tried to negotiate their work space around the barriers, while the non-STEM-group decided to leave the profession.

b) Quantitative group

Factor PCA2_2 summarised barriers in the organisation. It included items on the lack of promotion opportunities for women, the lack of management opportunities, the existence of a gender pay gap and poor salaries for women in STEM. It also included a lack of career opportunities for women in STEM. Surprisingly the STEM group scored 2.63 and the non-STEM group 2.66 on this factor. This indicates a tendency to deny that these issues are experienced as problems.

c) Theme 7 conclusion

The qualitative results showed that the STEM and non-STEM groups agreed that there were many work barriers. However, in the quantitative results the work barriers were presented as if they were not really an issue for women in the STEM fields, despite evidence to the contrary found in the relevant literature (Gnilka & Novakovic, 2017; Peña-Calvo et al., 2016; Urbanaviciute, Pociute, Kairys, & Liniauskaite, 2016).

7.3.2.8 Theme 8: Sources of self-efficacy

The sources of self-efficacy are mastery experiences, vicarious experiences, supportive experiences and emotional experiences. These sources were discussed in Chapter 3. In summary, mastery experiences refer to activities successfully executed, while vicarious experiences refer to seeing how others perform similar activities successfully. Supportive experiences (verbal persuasion) refer to verbal and emotional encouragement, and emotional/physiological experiences refer to physiological and emotional states that accompany actions.

a) Qualitative group

In the STEM group, two participants shared incidents of mastery experiences while more participants shared stories about vicarious experiences. Even participants in the non-STEM group shared incidents demonstrating vicarious experiences. In the STEM group there was ample evidence of experiencing verbal persuasion or supportive experiences, but no evidence of supportive experiences was mentioned by the non-STEM group. Two of the STEM participants related emotional experiences, but no-one in the non-STEM group shared experiences of this kind.

One aspect that did make an impression is the way in which the few women who did quote emotional experiences spoke about their passion for, enjoyment of and commitment to their STEM fields. When they spoke about their work and why they liked it so much, their satisfaction with the careers they had chosen was evident. It probably is not without reason that studies mentioned in Chapter 3 included work and study satisfaction as a prominent variable in their models. The more satisfaction one derives from one's studies or career choices, the more likely it is that one will be able to persist in a particular field of study or career trajectory. Satisfaction should also influence persistence and may be related to contextual barriers and support (Lent et al., 2013).

Usually mastery experiences play a prominent role with men when they quote sources of self-efficacy. Along with verbal support, modelling was also prominent with women in other studies. Maree et al. (2008) found that a combination of verbal persuasion and modelling played a role in the success achieved by women in STEM careers. This particular qualitative group emphasised enjoyment and passion, and one can postulate, in line with other findings about satisfaction (Singh et al., 2013, p. 282), that this factor was crucial as a source of self-efficacy, but also as a fundamental factor supporting the other aspects of self-efficacy. McGee et al. (2016), in a study undertaken to determine what motivated Black engineering students to complete a PhD, found that intrinsic motivation played a crucial role in the students' success. McGee et al. (2016, p. 186) explicitly mention passion for their fields, which crystallised as an "*unyielding drive to succeed*." Another study quoted the positive impression made by mentors and models who are passionate about their subject on women's decision to enter STEM (Zeldin et al., 2008, p. 1047).

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b) Quantitative group

Not many questions posed in the quantitative survey explored the issue of self-efficacy sources. Factor, PCA4_1 dealt with having poor perceptions about own abilities and, as can be seen from the scores of 2.16 for the STEM group and 2.03 for the non-STEM group, they did not have poor perceptions about their abilities as women.

In factor PCA4_3, which dealt with perceptions about gender, the STEM group scored 2.25 and the non-STEM group 2.19. This factor included questions about whether women should perhaps renounce their femininity or be less emotional when in STEM careers. The low scores show that the respondents did not agree with this suggestion. It is considered to be perfectly in order for a woman scientist to be feminine and emotional! The other question included in this factor asked whether women should believe in themselves and the mean score for the total sample was 4.7. Women expressed a very strong tendency for high self-belief or agency. Although this item did not load negatively on the factor, its high tendency was obscured by the low scores on the other items.

The following questions were posed to the STEM group only:

a. Q4.2_1 I enjoy my work (M = 4.28)
b. Q4.2_4 My work has a beneficial impact on others (M = 3.93)
c. Q4.2_6 I enjoy working with colleagues (M = 3.89)
d. Q4.2_7 I enjoy developing my skills (M = 4.45)
e. Q4.2_8 I enjoy doing research (M = 4.16)
f. Q4.2_9 I enjoy doing practical things (M = 4.20)
g. Q4.2_10 I set high goals for myself (M = 4.33)

The mean scores were relatively high and expressed the STEM group's enjoyment of their work and their passion for being involved in STEM work. Even skills development is very important to the STEM women and functions as a source of motivation for working in their field. Enjoyment and passion are emotional sources for increasing feelings about and their belief in their self-efficacy. It is possible that this passion and enjoyment, which underlie motivation and drive to a large extent, were not adequately emphasised in literature and previous research.

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c) Theme 8 conclusion

The absence of self-efficacy sources was telling in the non-STEM qualitative group, especially in their sharing of STEM experiences. The lack of sources underscores the low level of self-efficacy these women experienced with regard to their STEM studies and careers. Flowers III and Banda (2016) maintain that low self-efficacy due to poor mastery and vicarious experience is responsible for Black women leaking out of the pipeline. All four sources were evident from the stories of women in the STEM group. The fourth source of emotional/physiological experiences was emphasised in the section completed by the quantitative STEM group. They confirmed the importance of enjoyment, passion and commitment to their STEM careers. It seems as if the emotional experience of enjoying STEM and related activities, and experiencing satisfaction are important factors in women’s decision to remain STEM careers and to find solutions to obstacles such as family-work balance.

7.3.2.9 Theme 9: Education barriers

Although Blickenstaff (2005) and others, such as Schuster and Martiny (2017) and Cole and Espinoza (2011) (see Chapter 2) cite education barriers as an important reason why women do not enter STEM careers or stay in them, the qualitative results did not show much evidence of education barriers. It seemed that although many education-related barriers, such as a chilly classroom climate and discrimination against women in class played an important role in previous findings (Blickenstaff, 2005), as discussed in Chapter 2, its impact is not so prominent in the particular samples of this study.

a) Qualitative group

Two participants briefly referred to education barriers, but it was not very prominent. A participant in the non-STEM group mentioned that she could not get a bursary because of her gender. In essence, very little evidence of education barriers emerged from the responses of the qualitative participants.

b) Quantitative group

Factor PCA2_3, which dealt with barriers in education was scored 2.20 by the STEM group and 2.16 by the non-STEM group. It included items about existing prejudice against women in the classroom, experiencing negativity from both female and male students, being exposed to gender-insensitive curricula, teachers being prejudiced against women, experiencing the current education system as male orientated, and finally marginalising women in STEM in education (Blickenstaff (2005). Most of the questions obtained a score in the region of 2, which means that both groups denied these issues. In other words, they did not experience negativity

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in education while studying STEM. This finding does not agree with the model developed by Cheryan, Ziegler, Montoya, and Jiang (2017) to explain women's differential access to STEM. One aspect is the masculine nature of education practices and content preventing women from identifying with a particular career (this model is briefly discussed on page 288 below).

A neither positive nor negative trend was found in the women's perceptions of discrimination in primary and high school. Factor PCA4_2, which dealt with perceptions at school about girls in STEM had scores of 3.00 for the STEM group and 2.67 for the non-STEM group. The questions related to issues about the negative influence of primary and secondary schools, as well as the influence of teachers on negative perceptions of women in STEM. This finding also contrasts with Cheryan et al. (2017) explanatory model, which regards inadequate education experiences as one important reason preventing women from entering or remaining in STEM fields.

c) Theme 9 conclusion

From the qualitative discussion it was apparent that neither the STEM nor the non-STEM groups experienced many education barriers, especially at school level, and only a few barriers at university. The same was found in the quantitative results. As mentioned in Chapter 5, South Africa has implemented several programmes to make learners and teachers aware of the importance of allowing more learners, especially girls, into the STEM fields. While it is possible that these programmes are having an effect, the possibility also exists that women entering the STEM field simply do not experience education issues as salient problems.

7.3.2.10 Theme 10: Personal barriers

Personal barriers include issues such as what women think about themselves and issues related to maternity leave, bursaries, flexible working hours and more.

a) Qualitative group

One participant mentioned that more role models are needed in the STEM field. Other issues that were mentioned were the need for more flexible working hours and bursaries for women. Very few personal issues were mentioned. Charleston and Leon (2016, p. 161) reported a similar trend.

b) Quantitative group

The EQ provided more details about personal issues. Two factors can be discussed under personal barriers, namely Factors PCA3_2 and PCA4_3. Factor PCA3_2 dealt with personal barriers and included items that dealt with the difficulty of getting maternity leave and bursaries, and the fact that women in STEM lack self-confidence. The two groups did not express strong feelings about this factor and all scores were average or close to the midpoint. The STEM group had a mean of 3.11 and the non-STEM group a mean of 2.88. This trend was confirmed by the qualitative findings and other studies (Charleston & Leon, 2016).

The second factor, PCA4_3, which dealt with gender perceptions, was also discussed above, but to reiterate, it included items about women in STEM who needed to be less emotional and renounce their femininity. The two groups had no problem with emotion and femininity in terms of feeling that a woman in STEM should supress emotion or femininity. The mean scores for the STEM and non-STEM groups were 3.00 and 2.67 respectively. As stated above, the mean score obscures the low scores on two items and the high score on the belief item.

Although classified as a societal and workplace culture barrier, Factor PCA2_1 is also applicable under the theme of personal barriers experienced by women. The quantitative group regarded external barriers as a major problem. These barriers included hiring practices, recruitment practices, office culture, limited opportunities for women, science as a male career and women not being regarded as capable scientists. Factor PCA2_1 yielded a score of 2.60 for the STEM group and a score of 2.41 for the non-STEM group.

c) Theme 10 conclusion

The quantitative sample held a strong opinion about women's self-belief, irrespective whether it came from STEM or the non-STEM group. Note that femininity and emotionality were not regarded as problematic for women wanting to work in the STEM field. In the qualitative data personal barriers were linked to the lack of role models, lack of bursaries and rigid workplace policies in terms of working hours, leave, maternity leave and related issues. These findings were again contrary to the prominence given to these barriers in the literature (Cheryan et al., 2017; Wang et al., 2017).

7.3.2.11 Theme 11: Motivation to embark on STEM

a) Qualitative group

Several participants in the STEM and non-STEM groups mentioned that they had chosen careers in the STEM field because they enjoyed maths and science. This was discussed above under the fourth source of self-efficacy, which is emotional/physiological experiences, but may also be regarded as a strong motivational factor increasing the likelihood of embarking on STEM studies and remaining in a STEM career (McGee et al. (2016). One participant

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mentioned that she wanted to do something that could assist community development and contribute towards healthy families. It is interesting to note that McGee et al. (2016) mentioned that, along with passion, the desire to assist the community is an important motivator for Black engineering students to complete their PhD studies. A few participants said that they chose a career in science because they had grown up in a family of scientists or a brother or a father in this field. These motivations relate to vicarious modelling or having examples of significant people who had successful careers in the STEM field. These factors play an important role in research on minority groups entering the STEM field (Charleston & Leon, 2016; Flowers III & Banda, 2016). Motivation also refers to having people who verbally and emotionally support one's career decisions and path (Kassaee & Rowell, 2016; McGee et al., 2016).

b) Quantitative group

With regard to issues that play a role in motivating women to study STEM, two factors from the quantitative results are applicable. Factor PCA1_1 dealt with external motivation, namely the support and motivation provided by colleagues, lecturers, teachers, role models, friends and managers. The STEM group obtained a mean score of 3.09 and the non-STEM group's mean score was 2.87 – both of which were close to the midpoint. The implication is that there were no strong feelings about the support or lack of support from external people, which differs from the results of other studies that indicate that the support of teachers and others is important (Wang et al., 2017).

In contrast, Factor PCA1_2, which dealt with motivation and support received from individuals in the incumbent's inner circle, showed a slightly different picture. While the STEM group indicated that they were indeed supported and motivated by people in their inner circle (M = 3.41), the non-STEM group did not express strong feelings about this (M = 3.19). The items included dealt with the respondent's own interest in science (such as attending exhibitions, etc.), parents' support and interest in science, and partner support. The support of partners had a mean score of 4.27 (SD = .97), followed by parent support (M = 3.95, SD = 1.18). However, the item that contributed the most to internal motivation was own interest in science (M = 4.44, SD = .79). However, according to (Kinzie, 2007, p. 83), women who enter science with an interest in STEM eventually leave, although women who had participated in related studies indicated that their interest in science played a major role in their decision to enter STEM careers (Charleston & Leon, 2016, p. 157).

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c) Theme 11 conclusion

In both data sets the importance of personal interest was highly rated (Charleston & Leon, 2016; Nugent et al., 2015, p. 1071). The next most important factor was the motivation received from immediate family, followed by the support of friends and role players outside the family circle. Motivation and support from others are also related to verbal persuasion as a source of self-efficacy and might just as well be discussed in this section. However, the interesting aspect is the prominent role played by the immediate family. Although other role players such as teachers and lecturers are also important, the support and modelling examples of family members are crucial.

7.3.2.12 Theme 12: Leaving STEM

Both samples were confronted with the issue of why they considered leaving or did leave their STEM careers. The non-STEM group's reasons for leaving their STEM careers were mostly centred on family issues, having and raising children or supporting a husband's career. The majority of STEM women did not consider leaving.

a) Qualitative group

Several of the participants who had left the STEM field mentioned that it was not a family-friendly environment and that women did not receive support in this field. One participant said that she had left the field because she wanted to work with people. However, as was mentioned above on more than one occasion, their responsibility to their families was given as the main reason for women leaving their STEM careers. The participants who had remained STEM did not intend leaving, mostly because they were passionate about their work.

b) Quantitative group

The EQ included two questions about leaving or returning to STEM. These were:

a. (Q7.1_1) If you are currently in a STEM career, to what extent would you consider a change of career? The STEM group gave a largely negative answer, i.e. they would not consider leaving STEM (M = 2.19, SD 1.05).
b. (Q7.1_2) If you are NOT currently in a STEM career, to what extent would you like to return to a STEM career? The non-STEM group indicated that they would to a large extent consider returning (M = 3.14, SD = 1.17).

Some women in the STEM group (n = 31) also answered the second question, implying that if they did leave their STEM careers they would be likely to return (M = 3.84, SD = 1.24).

c) Theme 12 conclusion

Women in the qualitative non-STEM group did not intend to return the STEM field. Although they quoted family and children as the main reason for leaving, most were happy in their current careers and managed to achieve a balance between work and family life. Of course, it may be that the demands of a STEM career are so stringent that it is easier to manage a family and children with their current non-STEM careers. However, one could make a counter-argument by saying that some non-STEM careers, for example nursing, medically oriented careers or even service-oriented careers such as in the hospitality services, also make enormous demands on people's time. The quantitative results largely support the qualitative results: women in STEM intend to remain, while those in non-STEM do not intend to return. There are exceptions and it is difficult to generalise from only these two samples.

7.4 Summative remarks about the study's methodological approach

This study was an attempt to investigate the question of what the role of self-efficacy is in women's career trajectories in terms of keeping them on track. By simply asking why women stay in STEM careers if they have high levels of self-efficacy does not explain much if one does not ask the same question of women who had left STEM. The question is then: What does the fact that these women entered STEM careers, but later decided to leave, say about their levels of STEM self-efficacy? Although this study was intended to be explanatory, in other words, a causal study, to some extent the subject matter was such that a straightforward experimental design could not be applied. One cannot have an experiment where levels of self-efficacy and the fields in which women study and work are manipulated. Although the investigation of relationships between variables is possible, as was seen in Chapter 3, those studies were done with very specific samples restricted in scope and with measuring of specific variables.

One difficulty experienced in this study was the identification of women who had studied in the STEM field, but had subsequently left the field for some reason or other. In fact, women who had left STEM are not often included in a study, except in the case of longitudinal follow-up studies that track women from their studies to where they stand in particular jobs (Belser, Prescod, Daire, Dagley, & Young, 2017, p. 88). It was decided to do an exploratory study with the aim of investigating the possibility of comparing two groups, namely STEM and non-STEM, with reference to self-efficacy. The comparison was done on two levels, namely by way of a qualitative face-to-face study and a larger quantitative survey study. It was argued that a convergence of results could support assumptions about the role of self-efficacy in women's careers. The obvious way in which to do this was to follow a mixed-methods approach that would allow for two studies with similar aims to be done in parallel, with the results to be compared for some clues about the role of self-efficacy in women's careers and their decisions to remain in or exit the STEM field (Flowers III & Banda, 2016, p. 408).

7.5 Implications of Social Cognitive Theory for the career development of STEM/Non-STEM women

Recent research confirmed the importance of the role of self-efficacy in women embarking on STEM careers (Wang et al., 2017). Cheryan et al. (2017) developed a model to explain why women enter STEM careers in a differential manner. Their argument was that certain STEM careers do have sufficient numbers of women entering, such as chemistry and biology. However, women are still under-represented in careers in engineering, mathematics and computer science, at least in the US. The model they developed is comprehensive enough to account for the complexity and many subtleties in research about women in STEM. The three factors in the model of Cheryan et al. (2017, p. 5) are the following:

a. The prevalence of a masculine culture in computer science, engineering and physics. This culture indicates that women do not belong in these fields.
b. Education experience in computer science, engineering, and physics in early schooling is not sufficient to motivate girls and women to embark on careers in these fields.
c. The existence of gender gaps in self-efficacy in these three fields.

Issues similar to those discussed by Cheryan et al. (2017) under the first two points were raised in Chapter 2 of this study, but only one or two salient points about self-efficacy need to be mentioned here.

Cheryan et al. (2017, p. 17) report mixed results on the role of self-efficacy to explain women's differential access to STEM careers. For instance, some studies found gender disparities for self-efficacy in engineering and maths (see Chapter 2), but others found that women have higher levels of self-efficacy for engineering. The same applies to science and maths. Cheryan et al. (2017, p. 17) arrive at the following conclusion: "*These findings suggest that high self-efficacy may be insufficient to encourage women into STEM without remedying other factors (e.g., discrimination, inadequate academic opportunities)*."

The argument of the current study is that self-efficacy plays a crucial role in allowing women to remain in their STEM careers, while low STEM self-efficacy might be responsible for women leaving. As Flowers III and Banda (2016, p. 407) say: "*20 years of empirical evidence on the motivational construct of self-efficacy validates its relation to not only goals and choice of activity, but also to persistence as well.*" Given the quantitative findings one can argue that this is not the case. Women in STEM and women who had left STEM exhibit high levels of both occupational and general levels of self-efficacy. However, the qualitative results counter this finding with an understanding that women who had left STEM might not have sufficient levels of STEM self-efficacy, even though both the quantitative and qualitative samples exhibited high levels of self-efficacy for their current careers (which happened to be STEM for one group). A different result might be obtained if women in the survey sample were constantly reminded that they had to complete the questionnaire as if they still were in their STEM careers. The qualitative sample in this sentence provides sufficient evidence that women might have had low self-efficacy while in their STEM careers. In contrast to Cheryan et al.'s (2017, p. 17) remark above, i.e., that levels of self-efficacy should be seen against other barriers, the two samples in the current study showed that with the exception of the family-children barrier, most barriers did not constitute major problems.

The prominent role played by self-efficacy in these two samples can also be seen from the sources of self-efficacy. One of the most salient aspects was emotional sources of self-efficacy, which were also quoted as a strong source of motivation for staying in STEM. The experience of enjoyment, satisfaction, commitment and passion played a crucial role in both samples' reasons for staying in STEM (Sax, Lehman, Barthelemy, & Lim, 2016).

The support and motivation of family, i.e., close family, are important factors for entering and remaining in STEM fields. This has been found in other studies as well (Bahar & Adiguzel, 2016, p. 67; Dika, Alvarez, Santos, & Suárez, 2016, p. 34; Sax et al., 2016). Modelling family members, especially parents, are important, as is receiving emotional support from parents, spouses and immediate family. Teachers, for example, are also important motivators, but in the case of these two particular samples they were not considered to be as important as the immediate and close family. These findings can have implications for motivating girls and women to enter and stay in STEM, such as targeting those already in STEM and devising programmes for families that entered STEM (Coogan & Chen, 2007). This might be an under-utilised resource in programmes that are trying to cast their nets too wide (Schuster & Martiny, 2017).

7.6 Research conclusions

In summary, the researcher can say that the study did reach some of the objectives. The research conclusions are summarised in Table 62.

Table 62 Objectives and results of the study

No of objective	Objective	Result
1	To examine the role of self-efficacy in women who have established careers in STEM for at least three years or longer	The qualitative results showed that women in STEM careers have high STEM self-efficacy. The quantitative results confirm this finding.
2	To investigate the role of self-efficacy in women who had studied in STEM, but who subsequently left the field or made major career changes before entering careers in the STEM field	The qualitative results showed that women who had left STEM did not exhibit high levels of STEM self-efficacy, but showed evidence of high self-efficacy in their subsequent careers. The quantitative results confirmed that women who had left STEM had high levels of self-efficacy for their current careers, assuming that they completed the survey from their current perspective.
3	To determine whether women who have established careers in STEM differ significantly from those who made a career change with regard to self-efficacy	The qualitative study provided evidence for differences between women in the STEM and non-STEM groups, but the quantitative results could not unequivocally confirm this finding.

7.7 Limitations of this study

It is important to list the limitations of the study. Further study of the phenomenon of self-efficacy in women in STEM and women who left STEM will be insightful and could provide more and valuable information that could be useful for developing programmes targeting girls and women.

a. One limitation is the ability to generalise, although it was stated that this study was mainly an exploratory study. In order to develop the study into one that can be representative, a larger and random sample would be required, especially for the quantitative part.
b. A number of individuals started the survey but did not complete it, which contributed to a loss of information and a smaller realised sample.
c. It is difficult to trace women who had studied STEM, but subsequently left the field. As can be seen in the return rate for the quantitative part, even the women who volunteered to complete the survey were few.

d. Although a limitation of this study, an issue that could be addressed by future research is how STEM self-efficacy can be determined in women who had left the field. The suggestion was that they should be requested to complete the survey from the vantage point of someone still in STEM. The wording of items might also be changed. It would be worthwhile to make a comparison between STEM self-efficacy and current job self-efficacy.
e. The discrepancy between the way barriers were experienced, as discussed in the current study and how it is presented in the literature could be investigated. A tendency to deny the importance of barriers was found in the quantitative results.

7.8 Recommendations and contribution

This study made a contribution to research on this topic by uncovering the importance of the sources of self-efficacy in assisting women to remain in their STEM fields. A frequently under-emphasised aspect is that of the emotional source of self-efficacy, which this study found to be the passion, focus, enjoyment and satisfaction that motivate women to remain in STEM careers. It seems as if women leave STEM because of low STEM self-efficacy. A frequent problem pointed out in the relevant literature is that girls and women do not like STEM subjects and activities. However, the passion and commitment that were evident in some of the women who participated in this study counters this observation. Some women do like science and it is by no means a settled point that a lack of interest in STEM is gender-based. Programmes focusing on motivating women to enter and stay in STEM ought to take this particular source of self-efficacy into account. The question of course is whether one can instil passion, create interest and make STEM attractive to women. This is a separate topic for further study.

This study further highlighted the importance of inner-circle support and motivation for entering and staying in STEM. It is important that programmes be designed in such a way that families already in STEM will be encouraged to include their children, especially girls. Because of their very personal nature, motivation, support and encouragement from parents and close family function as major sources of self-efficacy. This calls for a creative approach to motivational programmes in order to make STEM commitment inclusive.

One aspect that was emphasised by women in both the qualitative sample and the quantitative results was the major importance of a personal interest in the field of science. In fact, this issue was even more important than the motivational support provided by close family. In essence, it relates to the passion expressed by women in STEM, but the importance of developing a strong interest in science cannot be overstated.

Finally, women as primary caregivers cannot be denied their place in their families. Women in and out of STEM all experience the pressures of having to maintain a balance between family and work. Some women manage to do this very successfully, while others cope by leaving STEM. It should, however, be pointed out that work pressures and expectations of family life and children also exist in non-STEM careers. Programmes dealing with women in STEM should take this issue very seriously and should assist women to manage and deal in a sensible way with the pressures of combining a family with a career.

7.9 Final conclusion

Increasing the numbers of women in STEM careers is not only a local or national imperative. It is a global necessity because women in STEM can contribute their passion and commitment to advancing science and the related fields. They also contribute to production and the global economy.

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APPENDIX A
INTERVIEW SCHEDULE

University of Pretoria

Department of Psychology

Main questions

1. Tell me about your current career and what it entails?
2. How many years have you been in this career?
3. Tell me the story how you landed in your current career?
4. What and who motivated you to choose a career in STEM?
5. Describe any difficulties you encountered as a woman in your career development?
6. What contributed to your success in your career story? For example: Which people, skills, beliefs, etc.?
7. Do you think that women in STEM face different problems from those encountered by their male counterparts?
8. Did you, as a woman, find it difficult to achieve success in your career?
9. How did you overcome these difficulties?
10. Which factors influenced your decision to remaining in / leave this field?
11. Which aspects of your professional career has so far been the most enjoyable?

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APPENDIX B

ELECTRONIC SURVEY: WOMEN IN STEM/NON-STEM

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DEPARTMENT OF PSYCHOLOGY

Survey

Biographical section

1. Record Number: ____________________
2. Full Name: ____________________
3. Current Company: ____________________
4. Current Position: ____________________
5. Years in current position: ____________________
6. Telephone (Home): ____________________
7. Cell phone: ____________________
8. Telephone (Work): ____________________
9. Email Address: ____________________
10. Postal Address: ____________________

____

11. Gender

Male	1
Female	2

12. ID Number: ____________________
13. Age: ____________________

14. Indicate your home language:

English	1
IsiNdebele	2
IsiXhosa	3
IsiZulu	4

Sepedi	5
Sesotho	6
Afrikaans	7
Setswana	8
SiSwati	9
Tshivenda	10
Xitsonga	11
Other (Specify):	12

12. Indicate your marital status:

Married	1
Single	2
Divorced	3
Widow/Widower	4
Married (traditional)	5
Living together	6
Other (Specify):	7

13. Indicate your highest educational level or equivalent (tick one):

Technikon Diploma	2
B-degree	3
Honours degree	4
Masters degree	5
D or PhD degree	6
Other (Specify):	7

14. Indicate field of study of your initial degree:

____

15. Indicate the field of study of your highest qualification

____

16. Are you currently in a STEM career:

____

17. Are you currently in a STEM career:

Yes	1
No	2

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In the following sections a number of statements are made. Indicate the extent of your agreement or disagreement by ticking the appropriate box that reflects your opinion about the statement. In some instances, the agreement will be expressed as "Never, To a small extent, To some extent, To great extent and Always" and with other questions "Not at all, Hardly true, somewhat true, moderately true and Totally true." Please read the statement carefully and provide the first response that comes to mind. Please be as honest as possible.

BOTH

Indicate the extent of your agreement or disagreement by ticking the appropriate box that reflects your opinion about the statement	Never	To a small extent	To some extent	To a great extent	Always
19 General questions					
19.1 To what extent would you regard yourself as successful in your current career?	1	2	3	4	5
19.2 To what extent did you find it difficult as a woman to achieve success in your career?	1	2	3	4	5

Self-Efficacy

Indicate the extent of your agreement or disagreement by ticking the appropriate box that reflects your opinion about the statement.	Not at all true	Hardly true	Somewhat true	Moderately true	Totally true
New General Self-Efficacy Scale (NGSES)					
I will be able to achieve most of the goals that I have set for myself.	1	2	3	4	5
When facing difficult tasks, I am certain that I will accomplish them.	1	2	3	4	5
In general, I think that I can obtain outcomes that are important to me.	1	2	3	4	5
I believe I can succeed at almost any endeavour to which I set my mind.	1	2	3	4	5
I will be able to successfully overcome many challenges.	1	2	3	4	5
I am confident that I can perform effectively on many different tasks.	1	2	3	4	5
Compared to other people, I can do most tasks very well.	1	2	3	4	5
Even when things are tough, I can perform quite well.	1	2	3	4	5
Occupational Self-Efficacy Scale (OSES)					
When I make plans concerning my occupational future, I can make them work.	1	2	3	4	5
One of my problems is that I cannot get down to work when I should. (R)	1	2	3	4	5
When I set goals for myself in my job I rarely achieve them.	1	2	3	4	5
When unexpected problems occur in my work, I don't handle them very well.	1	2	3	4	5
I avoid trying to learn new things in my job when they look too difficult for me.	1	2	3	4	5
When something doesn't work in my job immediately, I just try harder.	1	2	3	4	5

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Indicate the extent of your agreement or disagreement by ticking the appropriate box that reflects your opinion about the statement.	Not at all true	Hardly true	Somewhat true	Moderately true	Totally true
I feel insecure about my professional abilities.	1	2	3	4	5
As far as my job is concerned, I am a rather self-reliant person.	1	2	3	4	5
When something doesn't work well in my job, I give up easily.	1	2	3	4	5
I do not seem capable of dealing with most problems that come up in my job.	1	2	3	4	5
I can always manage to solve difficult problems in my job if I try hard enough.	1	2	3	4	5
(S) Thanks to my resourcefulness, I know how to handle unforeseen situations in my job.	1	2	3	4	5
If I am in trouble at my work, I can usually think of something to do.	1	2	3	4	5
I can remain calm when facing difficulties in my job because I can rely on my abilities.	1	2	3	4	5
When I am confronted with a problem in my job, I can usually find several solutions.	1	2	3	4	5
I am confident that I could deal efficiently with unexpected events in my job.	1	2	3	4	5
No matter what comes my way in my job, I'm usually able to handle it.	1	2	3	4	5
My past experiences in my job have prepared me well for my occupational future.	1	2	3	4	5
I meet the goals that I set for myself in my job.	1	2	3	4	5
I feel prepared to meet most of the demands in my job	1	2	3	4	5
General Self-Efficacy Scale (GSES)					
I can always manage to solve difficult problems if I try hard enough.	1	2	3	4	5
If someone opposes me, I can find the means and ways to get what I want.	1	2	3	4	5
It is easy for me to stick to my aims and accomplish my goals.	1	2	3	4	5
I am confident that I could deal efficiently with unexpected events.	1	2	3	4	5
Thanks to my resourcefulness, I know how to handle unforeseen situations.	1	2	3	4	5
I can solve most problems if I invest the necessary effort.	1	2	3	4	5
I can remain calm when facing difficulties because I can rely on my coping abilities.	1	2	3	4	5
When I am confronted with a problem, I can usually find several solutions.	1	2	3	4	5
If I am in trouble, I can usually think of a solution.	1	2	3	4	5
I can usually handle whatever comes my way.	1	2	3	4	5

Exploratory Questionnaire (EQ)

Both groups

Indicate the extent of your agreement or disagreement by ticking the appropriate box that reflects your opinion about the statement	Never	To a small extent	To some extent	To a great extent	Always
19.3 To what extent did the following motivate you to choose a career path in Science, Engineering & Technology (STEM)?					
Father	1	2	3	4	5
Mother	1	2	3	4	5
Teacher	1	2	3	4	5
My own fascination with science	1	2	3	4	5
Attending science fairs/exhibitions	1	2	3	4	5
Attending science programmes at institutions	1	2	3	4	5
A female role model	1	2	3	4	5
A male role model	1	2	3	4	5
Other (specify)	1	2	3	4	5

Both groups

Indicate the extent of your agreement or disagreement by ticking the appropriate box that reflects your opinion about the statement	Never	To a small extent	To some extent	To a great extent	Always
19.4 To what extent did the following factors contribute towards you remaining a professional in this field?					
I enjoy my work	1	2	3	4	5
I get acknowledgement for my expertise	1	2	3	4	5
I am regarded as an expert	1	2	3	4	5
My work has a beneficial impact on others	1	2	3	4	5
I can publish my work	1	2	3	4	5
I enjoy working with colleagues	1	2	3	4	5
I enjoy developing my skills	1	2	3	4	5
I enjoy doing research	1	2	3	4	5
I enjoy doing practical things	1	2	3	4	5
I set high goals for myself	1	2	3	4	5

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Indicate the extent of your agreement or disagreement by ticking the appropriate box that reflects your opinion about the statement	Never	To a small extent	To some extent	To a great extent	Always
My work has an international impact	1	2	3	4	5
My work has a great effect on the world	1	2	3	4	5
To what extent did you experience difficulties as a woman on your way to success	1	2	3	4	5
19.5 What role did the following play to overcome these difficulties mentioned above?					
Support of peers	1	2	3	4	5
Support of a manager	1	2	3	4	5
Support of friends	1	2	3	4	5
Support of my partner	1	2	3	4	5
Support of parents	1	2	3	4	5
To what extent did your personal life influence your professional life negatively?	1	2	3	4	5
To what extent did your professional life influence your personal life negatively?	1	2	3	4	5
To what extent would you regard yourself as a role model for women and girls wanting to embark on the same road?	1	2	3	4	5

Both groups

Indicate the extent of your agreement or disagreement by ticking the appropriate box that reflects your opinion about the statement	Never	To a small extent	To some extent	To a great extent	Always
19.6 To what extent was the following been a role model WHO ENCOURAGED YOU to become interested in STEM?					
Parents	1	2	3	4	5
Female achievers	1	2	3	4	5
Male achievers	1	2	3	4	5
Teacher(s) at school	1	2	3	4	5
Lecturer at varsity	1	2	3	4	5
Female colleagues	1	2	3	4	5
Male colleagues	1	2	3	4	5
Did primary school influence your perceptions negatively about science?	1	2	3	4	5

Indicate the extent of your agreement or disagreement by ticking the appropriate box that reflects your opinion about the statement	Never	To a small extent	To some extent	To a great extent	Always
Did high school influence your perceptions negatively about science?	1	2	3	4	5
Were some teachers prejudiced against girls doing maths and science?	1	2	3	4	5
Did you ever doubt your ability doing maths?	1	2	3	4	5
Did you ever doubt your ability doing science?	1	2	3	4	5
Did you ever feel you were not suited for a career in STEM?	1	2	3	4	5
To what extent are women's perceptions of STEM influenced by their teachers in a positive way?	1	2	3	4	5
To what extent are women's perceptions of STEM influenced by their teachers in a negative way?	1	2	3	4	5

Both groups

Indicate the extent of your agreement or disagreement by ticking the appropriate box that reflects your opinion about the statement	Never	To a small extent	To some extent	To a great extent	Always
20 Tertiary training					
20.1 To what extent did the following motivate you to pursue/ choose your field of study?					
Personal interest in science	1	2	3	4	5
Availability of bursaries	1	2	3	4	5
Parents interest in science	1	2	3	4	5
Teachers' motivation	1	2	3	4	5
Other (Specify)	1	2	3	4	5
20.2 To what extent did you encounter the following difficulties as a woman in your studies at your tertiary institution? (these could be psychological, institutional, cultural or technological)					
20.2.1 I doubted my ability to pass a STEM course	1	2	3	4	5
20.2.2 I faced negativity from male students in class	1	2	3	4	5
20.2.3 I faced negativity from female students in class	1	2	3	4	5
20.2.4 Lecturers were negative against women	1	2	3	4	5
20.2.5 My community regards STEM careers as not for women	1	2	3	4	5
20.2.6 I don't like technology	1	2	3	4	5
20.2.7 My parents made me believe that STEM is not for girls	1	2	3	4	5

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Indicate the extent of your agreement or disagreement by ticking the appropriate box that reflects your opinion about the statement	Never	To a small extent	To some extent	To a great extent	Always
20.2.8 Curricula is gender insensitive	1	2	3	4	5
20.2.9 The whole tertiary educational system is male dominated	1	2	3	4	5
20.3 To what extent during your training, have you ever been marginalized because you are a woman?	1	2	3	4	5

STEM group

Indicate the extent of your agreement or disagreement by ticking the appropriate box that reflects your opinion about the statement	Never	To a small extent	To some extent	To a great extent	Always
20.4 Which of the following barriers do women face today in STEM studies?					
20.4.1 Recruitment practises discriminate against women	1	2	3	4	5
20.4.2 Hiring practices	1	2	3	4	5
20.4.3 Women tend to have a lack of self-confidence	1	2	3	4	5
20.4.4 There is a lack of information on STEM careers	1	2	3	4	5
20.4.5 Lack of career opportunities for women	1	2	3	4	5
20.4.6 Lack of role models	1	2	3	4	5
20.4.7 A gender pay gap	1	2	3	4	5
20.4.8 Women are not as interested in science as men	1	2	3	4	5
20.4.9 The workplace is male dominated	1	2	3	4	5
20.4.10 The workplace discriminates against women	1	2	3	4	5
20.4.11 Women are not included in management	1	2	3	4	5
20.4.12 Women's career opportunities are limited	1	2	3	4	5
20.4.13 Women do not get promoted	1	2	3	4	5
20.4.14 STEM work is physically harder for women	1	2	3	4	5
20.4.15 People at work discriminate against me because I am or was young	1	2	3	4	5
20.4.16 I was hard to gain trust as a woman from older workers	1	2	3	4	5
20.4.17 Other women discriminate against me	1	2	3	4	5
20.4.18 Male discrimination just motivates me to work harder	1	2	3	4	5
20.4.19 Racism motivates me to prove myself	1	2	3	4	5
20.4.20 Racism is a bigger problem than gender discrimination	1	2	3	4	5

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Indicate the extent of your agreement or disagreement by ticking the appropriate box that reflects your opinion about the statement	Never	To a small extent	To some extent	To a great extent	Always
20.4.21 Balancing children with a career is difficult	1	2	3	4	5
20.4.22 Being married with a career is difficult	1	2	3	4	5
20.4.23 Professional women spent too much time at work	1	2	3	4	5
20.4.24 I do not have time for a family	1	2	3	4	5
20.4.25 Balancing career and personal life is difficult	1	2	3	4	5
20.4.26 Men at work make jokes about professional women	1	2	3	4	5
20.4.27 Racism at work is a problem	1	2	3	4	5
20.4.28 It is difficult to resume a career after taking maternity leave	1	2	3	4	5
20.4.29 Work hours are inflexible	1	2	3	4	5
20.4.30 Work does not cater for women with children	1	2	3	4	5
20.4.31 I would prefer working from home	1	2	3	4	5
20.4.32 Colleagues discriminate against women	1	2	3	4	5
20.4.33 Management discriminates against women	1	2	3	4	5
20.4.34 It is difficult to be a women manager	1	2	3	4	5
20.4.35 It is difficult to adapt to a male dominated environment	1	2	3	4	5
20.4.36 Sciences is seen as a male career	1	2	3	4	5
20.4.37 Women should not work in a technological environment	1	2	3	4	5
20.5 To what extent do you think these barriers can be overcome?					
20.5.1 These barriers can be overcome	1	2	3	4	5
20.5.2 It depends on how hard women work	1	2	3	4	5
20.5.3 Women should renounce their femininity	1	2	3	4	5
20.5.4 Women should be less emotional					
20.5.5 Women should believe in themselves	1	2	3	4	5

Non-STEM group

Indicate the extent of your agreement or disagreement by ticking the appropriate box that reflects your opinion about the statement	Never	To a small extent	To some extent	To a great extent	Always
20.6 To what extent did the following issues influence you to leave your intended STEM career?					
20.6.1 Recruitment practises discriminate against women	1	2	3	4	5
20.6.2 Hiring practices	1	2	3	4	5
20.6.3 Women tend to have a lack of self-confidence	1	2	3	4	5
20.6.4 There is a lack of information on STEM careers	1	2	3	4	5
20.6.5 Lack of career opportunities for women	1	2	3	4	5
20.6.6 Lack of role models	1	2	3	4	5
20.6.7 A gender pay gap	1	2	3	4	5
20.6.8 Women are not as interested in science as men	1	2	3	4	5
20.6.9 The workplace is male dominated	1	2	3	4	5
20.6.10 The workplace discriminates against women	1	2	3	4	5
20.6.11 Women are not included in management	1	2	3	4	5
20.6.12 Women's career opportunities are limited	1	2	3	4	5
20.6.13 Women do not get promoted	1	2	3	4	5
20.6.14 STEM work is physically harder for women	1	2	3	4	5
20.6.15 People at work discriminate against me because I am or was young	1	2	3	4	5
20.6.16 It was hard to gain trust as a woman from older workers	1	2	3	4	5
20.6.17 Other women discriminate against me	1	2	3	4	5
20.6.18 Male discrimination just motivates me to work harder	1	2	3	4	5
20.6.19 Racism motivates me to prove myself	1	2	3	4	5
20.6.20 Racism is a bigger problem than gender discrimination	1	2	3	4	5
20.6.21 Balancing children with a career is difficult	1	2	3	4	5
20.6.22 Being married with a career is difficult	1	2	3	4	5
20.6.23 Professional women spent too much time at work	1	2	3	4	5
20.6.24 I do not have time for a family	1	2	3	4	5
20.6.25 Balancing career and personal life is difficult	1	2	3	4	5
20.6.26 Men at work make jokes about professional women	1	2	3	4	5
20.6.27 Racism at work is a problem	1	2	3	4	5
20.6.28 It is difficult to resume a career after taking maternity leave	1	2	3	4	5

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Indicate the extent of your agreement or disagreement by ticking the appropriate box that reflects your opinion about the statement	Never	To a small extent	To some extent	To a great extent	Always
20.6.29 Work hours are inflexible	1	2	3	4	5
20.6.30 Work does not cater for women with children	1	2	3	4	5
20.6.31 I would prefer working from home	1	2	3	4	5
20.6.32 Colleagues discriminate against women	1	2	3	4	5
20.6.33 Management discriminates against women	1	2	3	4	5
20.6.34 It is difficult to be a women manager	1	2	3	4	5
20.6.35 It is difficult to adapt to a male dominated environment	1	2	3	4	5
20.6.36 Sciences is seen as a male career	1	2	3	4	5
20.6.37 Women should not work in a technological environment	1	2	3	4	5
20.7 To what extent do you think these barriers can be overcome?					
20.7.1 These barriers can be overcome	1	2	3	4	5
20.7.2 It depends on how hard women work	1	2	3	4	5
20.7.3 Women should renounce their femininity	1	2	3	4	5
20.7.4 Women should be less emotional	1	2	3	4	5
20.7.5 Women should believe in themselves	1	2	3	4	5

BOTH

Indicate the extent of your agreement or disagreement by ticking the appropriate box that reflects your opinion about the statement	Never	To a small extent	To some extent	To a great extent	Always
20.7.6 If you are currently in a STEM career to what extent would you consider a change of career?	1	2	3	4	5
20.7.7 If you are NOT currently in a STEM career to what extent would you like to return to a STEM job?	1	2	3	4	5
20.8 To what extent do you think women in STEM careers emphasize masculine traits and down play feminine traits?	1	2	3	4	5
21 Development of a career identity					
21.1 To what extent do you think that being a woman made a difference in your career success?	1	2	3	4	5
21.2 To what extent do the following factors in society's expectation of women prevent them from pursuing STEM careers?					

Indicate the extent of your agreement or disagreement by ticking the appropriate box that reflects your opinion about the statement	Never	To a small extent	To some extent	To a great extent	Always
21.2.1 Society believes women cannot do science	1	2	3	4	5
21.2.2 Society believes women should not do science	1	2	3	4	5
21.2.3 Women should stick to female roles	1	2	3	4	5
21.2.4 Society believes women cannot endure in STEM careers	1	2	3	4	5
21.3 To what extent do you think the following factors make it difficult for women to progress in their careers					
21.3.1 Not sufficient maternity leave	1	2	3	4	5
21.3.2 Poor salaries	1	2	3	4	5
21.3.3 No promotion opportunities	1	2	3	4	5
21.3.4 Competitive environment	1	2	3	4	5
21.3.5 Women are not regarded as capable managers	1	2	3	4	5
21.3.6 Women are not regarded as capable scientists	1	2	3	4	5
21.3.7 Office culture is discriminatory against women	1	2	3	4	5

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APPENDIX C

LETTER OF CONSENT

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Letter of Consent for the Study of Women in Science

Doctoral Student: Marinda Maree
Tel: 012 420 2505
E-mail: marinda.maree@up.ac.za

Supervisor: Dr Nicoleen Coetzee
Tel: 012 420 2919
E-mail: nicoleen.coetzee@up.ac.za

I am doing my PhD on the importance of social cognitive factors in the careers of women in Science, Engineering and Technology. The study is conducting in the Department of Psychology at the University of Pretoria.

An interview will be conducted with you to talk about your career development. The information will be recorded by means of note taking and by using a tape recorder. However, when recording the information for my study, your identity and any identifying details will not be disclosed. You will also be asked to complete a questionnaire either on the web or by emailing it to you. The purpose of the questionnaire will be support the information gathered in the interview. The results of these will be made available to you if you so wish.

You do not have to answer any questions that make you uncomfortable. You are free to end the interview at any point if you so wish.

I, ____, have read and understood this form.

By signing this form, I choose to participate in this research project.

___________________________	______________________	______________________
Participant signature	Date	Place
___________________________	____________________	______________________
Researcher signature	Date	Place

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APPENDIX D

BIOGRAPHICAL QUESTIONNAIRE FOR QUALITATIVE SAMPLE

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DEPARTMENT OF PSYCHOLOGY

Biographical Details

1. Full Name: ______________________________

2. Current Company: ______________________________

3. Current Position: ______________________________

4. Years in current position: ______________________________

5. Contact number: ______________________________

6. Email Address: ______________________________

7. Postal Address: ______________________________
____

8. Gender

Male	1
Female	2

9. ID Number: ______________________________

10. Age: ______________________________

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11. Indicate your home language:

English	1
IsiNdebele	2
IsiXhosa	3
IsiZulu	4
Sepedi	5
Sesotho	6
Afrikaans	7
Setswana	8
SiSwati	9
Tshivenda	10
Xitsonga	11
Other (Specify):	12

12. Indicate your marital status:

Married	1
Single	2
Divorced	3
Widow/Widower	4
Other (Specify):	7

13. Indicate your highest educational level or equivalent (tick one):

Technikon Diploma	2
B-degree	3
Honours degree	4
Masters degree	5
D or PhD degree	6
Other (Specify):	7

14. Indicate field of study of your initial degree:

____

15. Indicate the field of study of your highest qualification

____

16. Are you currently in a SET career:

____

17. Are you currently in a SET career:

Yes	1
No	2