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ABBREVIATIONS AND ACRONYMS

ACTO:	Accenture Consulting Technology Outsourcing
AMSPP:	Australian Maths and Science Partnerships Programme
ASSAF:	Academy of Science in South Africa
BRAOU:	Dr P. Ambedkar Open University
CAPS:	Curriculum Assessment Policy Statements
CIP:	Classification of Instructional Programmes
CPD:	Continuing Professional Development
CV:	curriculum vitae
DBE:	Department of Basic Education
DEST:	Department of Education Science and Training
DHET:	Department of Higher Education and Training
DoW:	Department of Women
DPME:	Department of Monitoring and Evaluation
DPW:	Department of Public Works
DST:	Department of Science and Technology
ECD:	early childhood development
EFA:	education for all
ETDP:	Education Training and Development Practices
GRB:	gender responsive budgeting
HEI:	higher education institution
HESA:	higher education South Africa
IBE:	International Bureau of Education
IRIS:	Interests and Recruitment in Science
i-STEM:	Awareness programme to improve participation of young women in STEM fields at South African universities
LLCs:	living-learning communities MDGs: millennium development goals
MEPI:	Middle East Partnership Initiative
MTSF:	Medium-Term Strategic Framework
NDP:	National Development Plan
NEPA:	National Education Policy Act

NEPAD:	New Partnership for Africa's Development
nGAP:	New Generation of Academics Programme
NGO:	non-governmental organization
NPC:	National Planning Committee
NRF:	National Research Foundation
NSE:	Natural Science and Engineering
NSERC:	Natural Science and Engineering Research Council
NSF:	National Science Foundation
NSLLP:	National Study of Living-Learning Programmes
NSFAS	National Student Financial Aid Scheme
NUC:	National University Commission
NYDA:	National Youth Development Agency
OECD:	Organisation for Economic Cooperation and Development
PISA:	Programme for International Student Assessment
SARS:	South African Revenue Service
SASA:	South African Schools Act
SETAs:	Sector Education and Training Authorities
SGB:	school governing body
SSAUF:	Staffing South Africa's Universities Framework
STEM:	science, technology, engineering, mathematics
STEAM:	science, technology, engineering, agricultural sciences and mathematics
SWE:	Society of Women Engineers
TVET:	Technical, Vocational Education and Training
UG:	undergraduate
UIS:	UNESCO Institute for Statistics
UNDF:	United Nations Development Fund
UNDP:	United Nations Development Programme
UNICEF:	United Nations Children's Education Fund
UN Women:	United Nations Women Organisation
UCDG:	University Capacity Development Grant
UNESCO:	United Nations Educational, Scientific and Cultural Organisation
US:	United States of America

USAID:	United States Agency for International Development
WISET:	Women in Science, Engineering and Technology

CHAPTER ONE INTRODUCTION

TO THE STUDY

1.1 INTRODUCTION

From my experience, which was also confirmed by the Department of Women (South Africa, 2015:34), the number of girls at the time of this study, was higher than that of boys in primary and secondary schools in most parts of the country. This raises an expectation that there should also be more young women than men at higher education institutions (HEIs) and in the various career fields. Indeed, the Department of Women (2015) reports that women constituted 57% of enrolment at HEIs in South Africa in 2010 and the number is said to be increasing every year. However, the most disturbing issue is that the number of young women is far lower in the fields of science, technology, engineering and mathematics (STEM) than that of young men and noticeably high in the social sciences fields. This scenario seemed to be the trend even in other countries. Reubena, Sapienzab and Zingalesc (2014:1403) report that women outnumber men in undergraduate enrolments in the United States. Surprisingly, very few of them major in mathematics or science. Moreover, only a small number of women choose these fields as professions as compared to men; hence the blame is passed on to negative sex-based stereotypes.

The situation of young women overcrowding some fields above others has been a cause for concern. There is therefore a need to determine what influences their choice of a career which results in low female enrolment in careers that are said to be scarce and critical. Research shows that the number of young women, particularly young black women, who are taking up careers in the STEM fields, is significantly low. Most young women choose careers in the health, education and welfare fields (Department of Women, 2015:43). This is not beneficial to the declining economic status of the country and to young women's future socioeconomic welfare. In addition, as briefly stated by O'Dea and Corcoran (2014:i), this situation creates a gender disparity in such career fields.

In view of this information, the questions that needed to be asked were whether young women chose careers based on the patriarchal stereotype that certain careers were

not meant for women, thereby avoiding anticipated complications that could be encountered in future should they decide to take up the role of child bearer by giving birth and breastfeeding, as mothers and wives. Another question that needed a response from this research was whether young women were aware of the gender disparity in the STEM fields in South African universities, as a result of their low numbers in those fields. A higher number of young women's choice of careers in those fields would enable them to participate effectively in the economy of their country, to rid the country of poverty and bring about socioeconomic empowerment.

Social change and transformation of the lifestyles of men, women and communities at large is said to be brought about by education. Hence education is regarded as the primary source of economic empowerment through equitable employment, business ventures and other related initiatives. Education is the most powerful instrument to fight poverty and improve the standard of living of needy and indigent communities (Department of Women, 2015:33). For young women to participate actively and also benefit from the economy of the country, they have to be empowered accordingly. Education, training and skills development serve as the main strategy to promote women's economic empowerment. Without these three components, young women may not know the what, why, how and when aspects of the economy within which they operate.

A good and consistently growing economy has been assigned to the hands of the STEM fields by the sustainable development goals, which also highlighted that equal access to these fields in particular, and to higher education in general, would lead to a more peaceful and prosperous world where there would also be the added bonus of gender equality. The STEM fields would enable the world to find solutions to threats posed by global challenges such as climate change, global health epidemics, and increased income inequality. This is in contrast to the survey that was conducted by the Manpower Group in 2015, which recognised that there was a global 'talent shortage' of 38% in the STEM fields, ascribed to women. In addition, the UNESCO Institute for Statistics (UIS) estimated that women comprised only 28% of scientific researchers across the world (UNESCO, 2016:1). This number is significantly lower than the remaining 72% occupied by men, which warrants the urgent need to close the gender gap.

According to UNESCO (2016:1), there is gender disparity in the STEM fields, due to women's often underrepresentation in this sector. These low levels of participation start and are visible at all levels of schooling, where culture and society have a great influence on the type of education suitable for girls and boys. The higher the level of education the greater is the decrease in female participation in the STEM fields. In turn, this regrettably influences the future labour market, where women's participation further decreases throughout their career path. As a result, women are also largely absent from higher-level managerial and decision-making positions. Because of this and other related issues, in its findings of Bangkok's 2015 publication: *A Complex Formula: Girls and Women in Science, Technology, Engineering and Mathematics in Asia,* UNESCO highlighted the importance of stimulating, encouraging and supporting fair and equal opportunities for girls to engage in STEM-related subjects at school. This report aimed to attract more girls and women into STEM fields as students and professionals.

In order to attract girls as students and women as professionals to the STEM fields, education, training and skills development should be aligned to the needs of the market. The activities at primary and secondary schools should instill the importance of the STEM fields in the learners' minds and be motivation enough to encourage them to choose such fields as careers, without hindrance. If the STEM subjects are given the attention that they deserve at those levels, learners, and in particular girls, would grow up and develop equally in such fields, as in the social science fields, which are currently preferred as careers. Considering the economic threats mentioned here, girls and boys, women and men should be enabled to freely access fields of their choice and for their equal benefit. If the STEM fields remain inaccessible to girls and young women as described, the country will continue to produce graduates that return home at the end of their studies, thereby adding to the problem of unemployment which is already excessive in South Africa. Young women should be encouraged to rise to the occasion because their numbers in STEM field careers are the lowest. The choice of careers by young women should be in line with the current needs of the country. Young women, however, should be stimulated, motivated and deliberately encouraged in the form of policy and programming to study and pursue professional careers in the STEM fields.

1.2 BACKGROUND

The world is experiencing socioeconomic challenges because of climate change and anxiety about food security. The STEM fields are the main solutions to the above challenges (Accenture Consulting Technology Outsourcing (ACTO), 2014:i). This report recommends that people should find a new home in the STEM fields, in order to overcome the crises mentioned. In this research, my aim was to encourage young women who were studying at universities and have the opportunity to select career paths that were critical and relevant to the era in which they were living. This implies that young men and young women should participate equally in the STEM fields in order to benefit optimally from the economic market and to live balanced lives.

Unlike their female counterparts, young men seem to be already aware of the situation around them as advised by the above report. Statistics across the European Union suggest that between only 6% and 7% of technical careers are occupied by women, meaning that the remaining 93% to 94% are occupied by men. The report finds it imperative that young girls and women are encouraged to take up STEM courses and participate in solving future problems (ibid.). The initial approach of this research was to encourage the young community as a whole to participate actively in the STEM fields but it was changed by the context of the report. Young men are already actively participating in the STEM fields in large numbers; the missing talent is that of young women. Their participation remains significantly low. As a result, I have taken the initiative to encourage young women to join their male counterparts, and participate actively in the STEM fields. The gender disparity in the STEM fields is a gap that needs to be closed, in order for South Africa as a developing country, to take lessons from European Union countries, most of which are developed, to be able to reach socioeconomic equilibrium among the youth community in particular and ultimately the nation at large, for sustainability.

As a developing country, sustainability in the competitive global market remains important and therefore needs to be maintained. This is implied by Hazari *et al*. (2017:1) when they report that the US has, in the past several years, been paying considerable attention to ways in which the talent pool in the STEM fields could be increased. On the other hand, research (Tjomsland 2009) indicates the deteriorating interest of students in the STEM subjects, which are said to be highly-paid and

rewarding. In particular, women have been underrepresented in those fields, which is a threat to economic growth and social equity. It was also reported that jobs in the STEM fields will increasingly require, as a minimum, a bachelor's degree.

The means to grow the economy and achieve social equity is said to be achieved through higher education. According to the World Bank Report (2009:2), 'Tertiary education is a key factor in a nation's effort to develop a highly skilled workforce for competing in the global economy'. Higher salaries, good employment opportunities and rapid upward mobility are part of the economic benefits of this education. The report also argues that graduates obtain social benefits, for example a better quality of life and good opportunities for the future. On the other hand, Tjomsland (2009:411) explains that the degree-awarding education that is offered at universities and institutions with the same higher education accreditation is often referred to as higher education in academic literature. For policy-related literature, the concept is referred to as tertiary education. In this study, university education is therefore understood to be the primary source of economic empowerment through equitable employment, business ventures and other related initiatives, leading to social change and transformation for the better, of the lifestyle of men, women and communities. Based on what is reported in this paragraph, I found South African universities as relevant institutions where the research to source out the best mechanisms to correct gender disparity in the STEM fields could, and should be conducted.

As previously mentioned, education, training and skills development, serve as the main strategies to promote women's economic empowerment. However, education should be relevant to the current era; training should respond to the needs of the market, and skills to be developed must be critical, necessary and required to close the gaps that inhibit the smooth economic growth of the country. The economy of South Africa is currently growing below the expected rate. As a caring South African citizen, I have taken the initiative to contribute through this research, to find an appropriate programme that would assist in improving the participation of young women in the STEM fields in South African universities since this is proposed as one of the best solutions to address climate change and the lack of food security crises. Hence for young women to participate actively and directly benefit from the economy

of the country, and not through their male counterparts, as their wives and employees, they have to receive social, economic and environmental empowerment.

Based on this information, it became clear that young women have been doing what they were not supposed to do and neglecting what they were supposed to be doing, i.e. they should have been taking up careers in the STEM fields in great numbers as their numbers are significantly low in such fields. They should also have enrolled in smaller numbers in the health, education and welfare fields since their numbers are already very high in those fields. The question that came to my mind was whether young women have been choosing the social sciences over the STEM skills because they were ignorant of the needs of the market or whether their choices had been informed by cultural and feminist stereotypes, or any other related aspect. That created a need to determine what influenced the choice of careers which results in the low enrolment of young women in the STEM fields that are said to be scarce and critical to the country's economy and also to determine how best this situation could be turned around.

What also came out clearly was that in order for young women's situation to be turned around, this research should contribute by creating awareness that young women were a missing talent in the STEM fields' pool. At the same time, this research had the duty, as a matter of principle, to make an effort to understand the experiences of young women, as well as the world around them. Through an awareness programme, this study would be encouraging more participation of young women in the STEM fields in South African universities, which is necessary for their own and the country's socioeconomic benefit. Since the World Bank Report (2009:2) recommends tertiary education, part of which is acquired at universities, as forming the nation's foundation for the development of a highly skilled workforce that can compete in the global economy, South African universities became important for this research.

1.3 RATIONALE FOR THE STUDY

There are gaps that are evident in relation to the choice of careers of young women in South African universities, particularly in the STEM fields. This creates an imbalance of skills acquired by young women since it creates an oversupply of social skills and undersupply of STEM skills. The possible impact of this is that young women who are

graduates in the social skills may find themselves without employment. On the other hand, there may be more than enough jobs with high salaries in the STEM fields which may unfortunately not be occupied by these young women because of a shortage of appropriate skills on their part. Consequently, young women may not be on the same socioeconomic wavelength as their male counterparts. This status quo results in a youth community which is not fully developed and equally balanced.

These gaps created an opportunity for the following goals to be aimed at in this research:

- Encouraging an improved number of young women in the STEM careers in South African universities;
- Persuasion for balanced acquirement of skills in the STEM and social fields for young women's socioeconomic empowerment;
- Inspiring sustainable/holistic youth development for the achievement of an adequately qualified youth community.

1.4 MOTIVATION FOR THE STUDY

According to Tjomsland (2009:411), the United Nations Development Programme's (UNDP) Human Development Index, which contains the statistics of women in higher education, reports that globally, women have the tendency to be overrepresented in the 'lower-level', 'soft disciplines' and short-term tertiary education. South African women are also reported by the Department of Women (2015:43) to have that tendency. Tjomsland (2009:411) further explains that while women in such countries tend to leave tertiary education at lower levels, what is most disturbing is the fact that women are under-represented in the technical and natural science fields. The unfortunate reality is that such fields offer 'well-paid' and 'high-status' jobs (ibid:412–13). For women to ignore the fields that deliver the benefits that are mentioned here, could only suggest that the motives were much stronger.

These reports served as sufficient motivation for me to desire to know the reasons why women do not take up careers in the STEM fields in numbers like their male counterparts. The high unemployment rate and poverty that are experienced in our country should have served to encourage young South Africans, especially women,

whose roles are child-bearing and breastfeeding, to prefer ‘high-status’ careers that also pay better salaries. Instead, the reports present the opposite and unfortunate scenario. Based on all this information, I was motivated to want to influence young women for their own socioeconomic welfare to take up careers in the better remunerated STEM fields.

1.5 STATEMENT OF THE PROBLEM

The world is experiencing unprecedented socioeconomic challenges because of climate change. As a result, the STEM fields are the main solutions to most of these challenges (O’Dea & Corcoran, 2014:i). Therefore, the gender disparity in the STEM fields is problematic and needs to be addressed. Although the country has established programmes towards youth development, young women’s development seems to be falling behind. If most young men choose careers that are sustainable, this will empower them economically and transform their lives for the better. On the other hand, young women will continue to stay at the bottom of the developmental pyramid and in all likelihood depend on their male counterparts for survival, as their employees or/and wives. South Africa needs to find a balance by implementing holistically developed programmes for the whole youth community, i.e. young men and young women. In this case, young women should be encouraged and actually supported to choose and pursue the STEM fields for careers, since such are scarce and critical for the economic development of the country and social transformation of South African society.

1.5.1 Basic research question

The main question of this research is: What is the responsive, awareness programme that could improve participation of young women in the STEM fields in South African universities?

The sub-research questions in response to the main question are:

- What are young women’s reasons for not choosing careers in the STEM as compared to social fields in South African universities?
- How can young women improve their participation in the STEM fields, in order to balance between such and social fields for enhancement of their socioeconomic empowerment?

- How enabling are the current university programmes for young women to choose careers in the STEM fields for their sustainable/holistic youth development?

1.5.2 Specific objectives

The following are objectives of this study:

- To determine the reasons young women do not choose careers in the STEM but in the social fields in South African universities and to encourage a change of this status quo;
- To encourage young women to balance the acquisition of skills in the STEM and social fields for their socioeconomic empowerment;
- To enable young women through programming, to choose careers in the STEM fields in South African universities, as an inspiration for their sustainable/holistic youth development.

1.6 SIGNIFICANCE OF THE STUDY

The aim of this research is to produce a responsive awareness programme to improve participation, by influencing and enabling young women in South African universities to take up careers in the STEM fields for their socioeconomic sustainability. Young women who participate in this programme will understand the importance of the STEM fields and their need in finding solutions to the current global warming, which continuously causes climate change, global health epidemics and increased income inequality.

Their participation as students and professionals will not only resolve the challenges mentioned above, but will also address the issue of gender inequality since men are already participating in large numbers in the STEM fields. As a result, young women would benefit by their appointment to high-level and decision-making positions in the labour market.

This study, through the developed awareness programme, will also make inputs towards policy amendments within South African universities, the government, through the departments that have been identified as key stakeholders, for example

Department of Science and Technology (DST), Department of Higher Education and Training (DHET) and Department of Women (DoW). This study will, most importantly, enable young women to take their rightful positions within the STEM fields, where they are currently the missing talent.

1.7 LIMITATIONS

The selected sampling for this research was limited by the capacity and availability of some participants, e.g. since the number of young women is reported to be lower than that of their male counterparts in the STEM fields, this research had to include young men as well for the completion of questionnaires. Another reason was that young men have mothers, sisters, female friends, etc. who live with them and share experiences on a daily basis. Therefore, the input from young men in the STEM fields was essential because through their questionnaires, young men made valuable contributions to this research topic.

1.8 DELIMITATIONS

Regarding the population selected for this study, I was aware that the activities at high schools might have a bearing on the preparation for choice of careers of learners, both male and female. However, for this study I focused on activities at South African universities, in relation to the choice of careers of young women only.

1.9 DEFINITION OF CONCEPTS

For this study, these concepts were necessary and defined as follows:

A. **Awareness:** Being mindful of something that exists, that can respond to the needs on the ground;

B. **Programme:** A set of planned and related activities and/or events, that would be implemented over a lengthy period, with the aim of achieving a particular goal;

C. **Improvement:** This means to change the status of something for the better or to enhance the condition or status quo;

D. **Participation:** In this research participation means involvement in the study and activities around the acquisition of a qualification in a certain career path;

E. **Young women**: A term used for females who are between 13 and 17 years old (Jakes, 2013:14); for this research young women are females between the ages of 18 and 35 who are students at South African universities;

F. STEM: This is a widely used acronym to mean science, technology, engineering and mathematics. The Department of Education (US) identifies STEM careers cluster as jobs in the fields of science, technology, engineering and mathematics, which involve planning, managing and providing scientific research and professional technical services, e.g. physical science, computer science and engineering, including laboratory and testing services, research and development services (Jakes, 2013:12).

F. (i) Definition of STEM

There are different definitions of the meaning of STEM. Muchie (2015:5) proposes the following:

Science: 'Exploring, understanding, knowing the humans, nature and the universe'.

Technology: 'The modification of the natural world to meet the human wants and needs. It helps us to improve our health; to grow and process food and fibre better; to harness and use energy more efficiently; to communicate more effectively; to process data faster and more accurately; to move people and things more easily; to make products to enhance our lives; and to build structures that provide shelter and comfort.'

Engineering: 'The profession in which a knowledge of the mathematical and natural sciences gained by study, experience, and practices is applied with judgment to develop ways to utilize economically the materials and forces of nature for the benefit of mankind.'

Mathematics: 'Any patterns and relationships; the science of numbers and their operations, interrelations, combinations, generalizations, and abstractions and of space configurations and their structure, measurement, transformations, and generalizations (*Webster's Ninth New Collegiate Dictionary,* 1985); together they as STEM reinforce each other with integration rather than moving along isolated trajectories.' White's (2014:4) definition of STEM is not far from that of Muchie's (2015:5) given above. The STEM fields are also explained based on the forms of academic careers, especially in science and mathematics, as follows:

- **Science:** The systematic study of nature and behaviour of the material and physical universe, based on observation, experiment, measurement and the formulation of laws to describe these facts in general terms.
- **Technology:** The branch of knowledge that deals with the creation and use of technical means and their interrelation with life, society, and the environment, drawing upon such subjects as industrial arts, engineering, applied science, and pure science.
- **Engineering:** The art or science of making practical application of the knowledge of pure sciences, as physics or chemistry, as in the construction of engines, bridges, buildings, mines, ships, and chemical plants.
- **Mathematics:** A group of related sciences, including algebra, geometry, and calculus, concerned with the study of number, quantity, shape, and space and their interrelationships by using a specialized notation.

These definitions provide a clear description of each of the fields falling under STEM. This is to ensure the understanding of these fields in general, to differentiate each from the other but also to show the relationship and links among all of them. Their functions and activities are somehow embedded in these definitions.

1.10 CHAPTER OUTLINE

Chapter one introduces the title of the research, its rationale and the background against which the research is conducted. It also provides an overview of what should be expected in the rest of the research process. In chapter two, a preliminary literature review is outlined. The ideas of different experts on the subject of this research are explored. This includes practices that are implemented by different countries as lessons that may be learnt by South Africa.

Chapter three discusses the literature based on the theories selected for this study. These theories outline, among others, the nature of a female and a woman in trying to understand if the choice of young women's careers is influenced by their nature as females and women or by any other aspects outside this. This assisted the research to confirm or dispute the influence of such theories in the choices of careers of young women and assisted the process of data analysis to ensure valid outcomes.

In chapter four, the methods used to collect data and designs are explored, approaches are outlined, sampling procedures followed and there is an analysis of collected data. The quantitative and qualitative methods were used simultaneously due to the number of participants that were targeted to complete the questionnaires. Thereafter, the analysis was integrated and also done side-by-side. Chapter five presents the conclusions of data which was analysed as well as the findings of the research. It also provided my recommendations as the researcher, which also has implications for policy and governance regarding the contribution towards improving the participation of young women in the STEM fields in South African universities. The final and sixth chapter contains the awareness programme that gives guidance on how to improve the participation of young women in the STEM fields in South African universities.

1.11 SUMMARY

In conclusion, this chapter presents the problem which has been investigated, i.e. the lower number of young women in the STEM fields, despite their higher numbers at South African universities in general. Universities, as part of higher education, have been recommended as the best tool to assist any nation to eradicate poverty. With large numbers of young women already at these institutions, the ground has been prepared for universities, through intentionally devised programmes, to discourage young women from taking up careers that are already overflowing and instead to encourage them to pursue their studies in the STEM fields where their numbers are significantly lower than those of their male counterparts. However, the continued tendency of young women to take up careers away from the STEM fields, displays a gap in the programmes that they are exposed to when entering university. As a result, this study has intervened through a programme born from the findings of the investigation.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter reviews a wide range of literature that speaks to young women in the STEM fields. A comparison is made between the position of young women in these fields in other countries and their situation in South Africa and in particular, at South African universities. Lessons were learned where the situation has improved. The measures put in place to realise such improvements were taken as recommendations for the development of an awareness programme, aimed at improving the participation of young women in the STEM fields in South African universities, as the outcome of this study. In this chapter, acknowledgement and appreciation of the efforts made so far by participating institutions, i.e. universities and government, are given by embracing such efforts as inputs, with the hope of collaboration in the implementation of the developed programme.

2.2 BACKGROUND

A number of programmes and initiatives have been established and implemented since the inception of a democratic government in South Africa. During the transitional period from apartheid to democracy, many people, especially those in vulnerable groups like women, have been undergoing rapid transformation, trying to cope with changes from the Old Order towards the new direction that the country was taking. New challenges and the changing traditional gender roles became a reality for many while people were simultaneously facing a socioeconomic crisis. Improving women's participation in reclaiming their share of resources, land, employment and income relative to that of men, was seen as necessary and sufficient to effect a dramatic change in their living conditions (Miles, 2000:1). These are some of the reasons why I considered that young women should 'claim' their socioeconomic space by participating in large numbers in the STEM fields, with market-related salaries.

Changing gender roles was a small factor of what the world, not only South Africa, had become. Technology had become more advanced and people, particularly mothers as primary providers for families, could no longer rely on subsistence farming for food

security as the only source of income due to global warming (ACTO 2014:i). As a result, empowering women and girls has become a priority as well as ensuring that they received investments equal to those of their male counterparts for their sustainable growth. On the other hand, young people were regarded as a positive force for development and needed to be provided with the knowledge and opportunities to thrive. Significantly, young people were encouraged to acquire the education and skills which were, and still are, necessary to contribute towards a productive national economy (United Nations, 2015:1).

Based on this background, the purpose of the study is therefore to assist young women to:

- embrace the changing gender roles
- engage in relevant education
- acquire the necessary skills
- maximise their economic investments
- live sustainable lives.

When consolidating and contextualising the above objectives, the intention of this study is to improve the participation of young women in the STEM fields, which seems to be one of their new roles compared to the former one of flooding the social and humanity fields as if this was the norm. Young women are encouraged to break the barriers and enter the male-dominated STEM fields in large numbers, in order for them to avoid poverty instead of mostly pursuing fields that no longer provide good returns and, in addition, are also over-supplied. The level of education at which that is achieved is important since a university is one of the finest institutions where young women are enabled to construct the foundations of their future careers that in turn will lead to a sustainable livelihood. Young women should also break the glass ceiling and take up leadership positions in the workplace, as professionals.

According to the British Council (2015:3), the issues around women and their inclusiveness in leadership positions, were discussed at the UN Conference in 1935. Regrettably, such issues are still discussed up to the present. The three highlights are women in the STEM fields, their entry, retention, respect and recognition in such fields.

The same problems that were identified as challenges are still obstacles and continue to persist even into the 21st century. The main question that remains unanswered is whether society has put sufficient effort into addressing such issues. Alongside the main question one should ask whether women scientists are being nurtured; have there been enough opportunities for them throughout the past years, and whether academies and institutions of learning have been giving women the honour they deserve. Universities, as part of these institutions, who already enjoy the pleasure of registering a higher number of young women than young men, need to respond to the above questions. They should reflect on what measures they have put in place to ensure that this high number of young women registered does not overwhelm one area or even a few disciplines but is proportionally spread throughout the fields, especially in those where women's talent is missing, as in the STEM fields.

2.3 OVERVIEW OF STEM EDUCATION

2.3.1 Significance of STEM for development

According to Muchie (2015:4), STEM integration, comprising science, technology, engineering, and mathematics is a new unity of knowledge of related disciplines, to the extent that crossing from one to the other as a resource for learning and invention is regarded as important, necessary and relevant. This new trans-disciplinary field of education and its integrated knowledge resource is enriching for learners since it enables them to create meaning of the world through a broader disciplinary lens than if it were viewed through bits and pieces of phenomena, in their own isolated fields.

In all fields of work, career development has been found to be significant and critical. The development in the field of science, technology, engineering, agricultural sciences and mathematics (STEAM), in particular, is important in improving the underrepresentation of women. Women are encouraged to continuously develop themselves at different stages and levels of their careers. They need to acquire new skills and abilities, in order to gain access to senior decision-making positions and as leaders (Cummings, 2015:25). Training and development for girls and women in the STEM is necessary and can be done on a global scale as in the case of the Microsoft Global Women's Hackathon. This institution tested, validated, and also packed curricula in the form of 'learning kits', after which it was taken to different institutions

around the world. This initiative is currently raising women's and girls' interest in computer sciences worldwide, successfully. The other initiative, the United States Middle East Partnership Initiative (MEPI) Women in Technology, is empowering women in the Middle East and North Africa. It is cosponsored by Microsoft and the Institute for International Education. This network has been providing training in information technology since the year 2005, on professional development and entrepreneurship, to over 10,000 women from underprivileged communities (Cummings, 2015:28). South Africa can also take lessons from the above practice, towards the development of women in the STEM fields.

Cummings (2015:28-29) mentions another example of 'the powerful use of a digital community', i.e. the STEM Camp for African Girls on Robotics and Renewable Energy. This is an initiative of Working to Advance STEM Education for African Women Foundation (WAAW). So far, this initiative has taken up to 62 girls who have taken part in a STEM camp. The WAAW has undertaken to send 10,000 girls, from secondary schools and colleges, on programmes. It has also trained 120 college partners and awarded 17 college scholarships. On the other hand, the European Platform of Women Scientists provides 12,000 women at senior levels, in 40 countries with 100 digital and real networks. The collaboration of different organisations mentioned above heightens the outcome results. This serves as motivation since they used various strategies towards the achievement of a common goal for all, i.e. development of girls and women in the STEM.

In assisting the above and many more initiatives in the development of women in the STEAM for certain countries, as explained by Cummings (2015:31-33), a gap has been identified, that of reliable, well-structured data, in order to keep track of women who are working in the STEAM, research and educational institutions but regrettably, some data is not sex-disaggregated. The aim of securing quality data is for evaluation of the current status of gender equality initiatives in academic research in the STEAM fields in Africa, Euro-Asia, Southeast Asia, Latin America and the Caribbean. The underlying objectives behind this aim are to be able to:

- Provide baseline information on the existing gender gap in the STEAM globally. Identify how the above gender gap affects different levels of seniority within the STEAM fields.
- Compile disaggregated data in academia in order to provide patterns that may assist in understanding the trends in women's participation and retention in STEAM fields.
- Review integrated STEAM programmes for women in different countries, including those that may not have the necessary resources for implementation.
- Identify challenges, including different forms of gender-based violence that women are faced with, from joining to staying successfully in STEAM fields.
- Highlight successful programmatic practices and lessons, in order to support women to thrive in STEAM fields.

In summarising the above, Akinsowon and Osisanwo (2014:8) explain that STEM plays a significant role in the development and economy of all nations, as it forms the 'basis for the different emerging technologies' that the world activities revolve around. As a result, the development of girls in STEM is important, considering the role they play in society as future mothers. These authors suggest that once more girl-education is emphasised in Nigeria, there will be a 'healthier, more educated, more empowered and more productive nation'. The placing of young women at the centre of the development in the STEM fields will drastically change their marginalisation and assist them to balance the choice of careers by taking up more in the STEM fields, where their numbers are low in the upliftment of their socioeconomic status. This will address the much-needed 21st century skills.

2.3.2 Historical features of STEM

White (2014:2) claims that all forms of STEM education have been around for decades without serious acknowledgement. It is only now that legislators and educational administrators are recognizing its importance. Originally, STEM education was referred to as science, mathematics, engineering and technology (SMET), initiative of the National Science Foundation (NSF). The aim of this initiative was to provide all students with critical thinking skills that would enable them to creatively solve problems and become the ultimate workforce in that market. In support of that, O'Dea & Corcoran,

(2014:i) implied that the aim still stands as STEM is regarded as the solution in the unprecedented socioeconomic challenges that the worlds find itself, as a result of climate change and shortage of food security.

In essence, White (2014:2–3) highlights that historically, the STEM concept was being implemented in many areas in the business sector, as part of the Industrial Revolution. STEM was primarily used in engineering firms to produce revolutionary technologies such as the light bulb, automobiles, tools and machines. A number of inventors of these and more innovations were not highly educated and some were in different types of apprenticeship. For instance, the people who used the STEM principles (although there was no STEM then) to produce some of the most productive technologies in history, Thomas Edison and Henry Ford, did not attend college.

The wealth of knowledge that is available today serves as a great opportunity for further development in the form of programmes to be initiated, in the effort to increase the participation of young women in the STEM, and towards greater sustainability.

The development of the land grant universities, as a result of the Morrill Act of 1862 that initially focused mostly on agricultural training but soon thereafter included engineering-based training programmes, is one of the historical efforts that gave birth to STEM education (White, 2014:2–3). Subsequent to that, the Ohio State University was established in 1870, although it was originally named the Ohio Agricultural and Mechanical College. Thereafter, more land grant institutions were established, also growing the STEM education training, which ultimately was integrated into the workforce. In addition, some historical events like World War II and the launch of the then Soviet Union's Sputnik, also added to popularise STEM education (ibid.).

Since the inception of the then SMET to the current STEM, there have been various developments that have contributed to knowledge that was gathered as heritage for us to use today and in future. The incentive is that, as mentioned above, most of this knowledge originated from people who were not professionals but they still managed to pass their knowledge to the following generations. More inventions are yet to come and both men and women have to make equal contributions to maximise their production. However, both genders need to be at the same level of development. Young

women therefore deserve to participate equally in the excitement of new creations and have to be assisted through developmental programmes, hence this investigation was conducted, through which the birth of an awareness programme was realised.

2.3.3 Contemporary features of STEM

The importance of history in the development of the STEM education cannot be underestimated and continues to occupy that space. There are currently a number of varying opinions by different stakeholders, on what STEM education is and how it should be taught (White, 2014:4).

Regrettably, Akinsowon and Osisanwo (2014:8) relate how different surveys, throughout the African continent have discovered a higher record of boys who are studying science and technology subjects and perform significantly better than girls. This leads to boys pursuing the STEM careers beyond their schooling. Girls, on the other hand, take different career paths away from the STEM fields and even the research field. The results are that women tend to be in the minority in both these fields and their influence in policymaking remains limited. Girls and women have to be attracted to pursue STEM careers in bigger numbers, considering their minority status in these fields.

What these authors refer to as ‘Situational Interest’ (Akinsowon & Osisanwo, 2014:10), is said to be triggered by the environment, due to the ‘state of actual attraction or curiosity as well as increased attention’. This means that the environment plays a greater role in making science interesting for women or the opposite of that. In some cases, the ‘teacher’ factor’ becomes the cause for girls to dislike science, i.e. the perceptions and attitude of STEM teachers in schools may be discouraging, whereby teachers give more attention to boys than girls and offer them more opportunities for hands-on practical work while the girls are almost ignored. This is one form of gender discrimination born of harmful cultural stereotypes, discouraging women from taking their rightful place in the STEM fields.

The ‘home factor’ is yet another discouraging aspect, where women want to balance family life and personal relationships while at the same time trying to secure a successful career in the sciences, which often becomes impossible. The two challenges

mentioned above, embracing child care and operating a research laboratory are competing. It is also reported that women who plan to have children in the future, drop out of the professional research careers at twice the rate of men (Akinsowon & Osisanwo, 2014:10). In addition to this, curriculum development can also be discouraging to both men and women. An example is the introductory part of computer science, which focuses on programming (ibid:11). The need for amendment in the curriculum is another factor that has to be integrated with the delivery of that curriculum, to enable full access to the STEM. Flexibility to balance home and work activities within the STEM sector also needs to be researched.

In trying to curb the above and many more contextual factors that inhibit the taking up of careers in the STEM by girls and women and in closing the gender gap in the STEM representation in Nigeria, Akinsowon and Osisanwo (2014:11) suggested the following:

- Adequate preparation of the girl for STEM; preparing girls for good mathematics skills starts with the right mindset and confidence to handle the subject well. Therefore, teachers need to be trained on how to relate to those female students who may have a preconceived idea that the STEM fields are difficult.
- Another perception that the STEM fields are meant for men needs to be corrected. The promotion of a positive image of women in STEM is a key factor.
- All gender bias and stereotypes should be removed from society and communities, in particular, parents, curriculum developers, school administrative staff, educators and trainers.
- Girls should be exposed to female role models who have 'excelled in their STEM careers and equally do well as mothers and wives' from an early age. This includes enabling them to access STEM education and counselling on the importance and need for them to take up a career in the STEM fields. Activities such as career exhibitions, job shadowing, talks on STEM fields, creativity education, workplace and science educational tours, science expos, etc. should be organised frequently.

- Award ceremonies should be organised for women in STEM. Scholarships, from local and international organisations should be sourced from bodies and associations such as Anita Borg Scholarship; Grace Hopper Celebrations for Women in Computing; Schlumberger Foundation Faculty for the Future; the World Bank-funded Science and Technology Education Post-Basic (STEP-B) Project; Exxon Mobil Education Initiatives (MPN); Schlumberger Excellence in Education Development (SEED); Strengthening Mathematics and Science Education Project (SMASE), and so on.
- Competency-based learning activities should be introduced into the teaching of STEM. This will assist to make courses perceived as real and not theoretical. It would also help to make the learning environment of STEM more attractive.
- Another programme that has a strong impact on the female is mentoring. If it is active and properly implemented, it has a modelling effect and also helps to build confidence, clearing the gender stereotype that has been attached to STEM. Research has shown that mentoring programmes from primary to secondary school levels can result in great improvements in the learners' academic performance, attitudes and self-confidence. Girls attending secondary schools and studying the STEM subjects could serve as mentors for younger girls in primary schools. Similarly, female scientists could serve as mentors for young women at universities.

The above mentoring layers could also benefit the mentors, since they develop leadership skills when mentoring their assigned mentees and at the same time, they receive advice from their own mentors to pass to their mentees.

2.3.4 Foundation of STEM in Africa

According to Muchie (2015:6-7), Africa is the 'cradle of humanity', since civilisation, astronomy, science, mathematics and philosophy originated from this continent. The deep and rich culture invented by the African ancestors should be used to transform the current challenges into a 'beautiful tomorrow' by the African people of today. All

scientific discoveries contributed by Africans are evidence that has been acknowledged by astronomers and engineers from Western research universities that have been recording the major inventions made by Africans. For example, some 2000 years ago, carbon steel was made in Tanzania; there were astronomical observations in the Mali of the Dogons that were acknowledged by Carl Sagan of Cornell University. Africans have also invented language and communication, writing systems, mathematical systems, architecture, agriculture, cattle-rearing, navigation of inland waterways and open seas as well as medicine. The South African example of the gold artefacts that were discovered in Mapungubwe in 1933 by the University of Pretoria bears testimony to this assertion that Africans have long been contributors to the knowledge of science and engineering (www.creamermedia.co.za).

Africans have a very rich knowledge of agriculture and in 1996 the US Academy of Science recognised and fully acknowledged that Africa has more native cereals than any other continent. Africa has its own species of rice, finger and peral millets, guinea millet, fonio, sorghum, teff and a number of different wild cereals whose grains are eaten. This food heritage has been feeding people for many decades and generations. It can form a base for manufacturing many other types of food to be used in the future. Although all these have been avoided in modern times, visionary scientists are starting to reconsider the old cereal heritage with future plans, not only for Africa but the world at large. For instance, the Ethiopian crop, teff, is used as medicine, despite its use as a healthy nutritional food (Muchie, 2015:8). Young women in South African universities could join the STEM fields and take their share in the further discoveries of the African continent in general and South Africa in particular.

Muchie (2015:9) also reported on the recent release by the BBC4 television channel, revealing an ‘amazing method of mathematical calculation’ with commentators from the Open University in the United Kingdom, explaining that there was an ancient Ethiopian mathematics. It demonstrated that Africans used binary logic in mathematical calculations similar to the Internet explorer used today and other computer-based systems. The fourth industrial revolution could benefit from all angles should the world open up the contribution that Africa and Africans in particular have made and can still make. The continued empowerment of young women in the STEM could strengthen the generation of new knowledge in these fields. The world as

indicated by Muchie (2015), used to learn from Africa not only as knowledge consumers but also as contributors of new inventions.

One of the latest, very inspiring African innovations came from South Africa, whereby a seventeen-year-old young man, Ludwick Marishane, invented a waterless bathing lotion and was awarded the Global Student Entrepreneur of the Year Award in 2011. This lotion is innovative since it prevents various diseases due to the lack of proper sanitation. The invention is promoting water saving around the world and it allows for limited access to clean water by people, as is currently the scourge in some rural areas. Ludwick conducted the research with a previous-generation cell phone and an allowance of R50, to arrive at his invention; the lotion with a formula which is currently untested (Muchie, 2015:10).

This is testimony to the fact that with the necessary resources and infrastructure, Africa could occupy its rightful position in the nations of the world. Surely there are young women in South African universities, who can match the discoveries of Ludwick. Universities could lead transformation in the STEM fields by the empowerment of young women through the right programmes.

Muchie (2015:11) also suggested integrating a ‘total invention innovation’, transforming Africa through the same knowledge that it has invented in the past but also learning some lessons from other practices to embrace such innovation, as well as acquiring competent building systems skills. There is a need to establish a ‘Pan African Innovation System’, learn and also form new inventions from the past foundations in the STEM, ‘by Africans for Africa’. African values have proved to be sustainable and may be used for more innovation in STEM, without contravening communal and environmental health. The construction of new knowledge and innovation with STEM at the centre would develop a fresh path that will mark a new era for the African Union New Partnership for Africa’s Development (NEPAD) towards a very active African transformation and innovation system. The STEM integrated African transformation, as explained by Muchie (2015:12), starts with change in the education system. This means that STEM education must be compulsory at all school levels. It should be as natural as the clicks that are part of the African languages through African invention.

The continent of Africa has contributed substantially to the STEM fields with some of the inventions forming the base and foundation for further discoveries. Innovation and creativity are not confined to a specific continent and young people today can positively make a difference should an environment conducive to development be created.

2.4 POLICIES AND INITIATIVES ON STEM

UNESCO (2016:2) contends that the low participation of girls and women in STEM originates from a number of factors. Some of these factors emanate from socio-cultural preconceptions to perceptions assigned to women in the labour market that ultimately influence their career choices.

Such philosophies turn to construct views among young people, on the types of professions perceived to be suitable for women or for men. Education, in the form of gender-sensitive policies and frameworks, is important to turn that situation around. The learning materials, as the driving force behind that education, should be free from gender stereotypes, for the benefit of both learners and teachers. The attitudes of learners towards the STEM subjects should be deliberately aligned and stimulated towards sustained achievement in these fields, to ensure easy access for future career choices. Creating the right atmosphere for young women will enable them to participate more in the STEM. Universities therefore need to ensure such an environment through training lecturers in gender-sensitive programmes, running the relevant projects, as well as developing policies that match world standards in that regard.

Since there is a great need for girls and women to join the STEM fields worldwide, UNESCO (2016:2-3) has been working on a number of different projects that are building momentum around this issue. One such project was the establishment and observation of the first ever International Day of Women and Girls in Science on 11 February 2016. UNESCO is also conducting research on girls' education in science and mathematics, which will investigate their participation globally. Its Institute for Statistics (UIS) is embarking on a STEM and Gender Advancement project, with the aim of reducing the gender gap in the STEM through analysis and development of

new indicators. This will bring about a clear understanding of the dynamics that influence women's participation in these fields as well as support evidence-based policy-making. The UNESCO International Bureau of Education (IBE) has been working with the Malaysian government since April 2015, to strengthen the STEM curricula, teacher education and assessment for girls and women. All these initiatives display UNESCO's effort to mobilise the world, calling upon member-states to take vigorous actions to draw more girls and women into STEM for a 'more peaceful and sustainable future'. South Africa, as a member-state of UNESCO, can also take lessons and advantage of the initiatives that are offered in the effort to improve the participation of young women in the STEM fields.

Cummings (2015:27) suggests that gender quotas be used as a policy instrument that will expedite woman's participation in the STEM, since it will fast-track changes in the gender imbalances in these fields. However, gender quotas require a top-down approach or else the issue may be controversial in environments such as academia, where the merit system is preferred, even though the current merit systems seem to be favouring men over women. The gender quota system has succeeded in countries where it has been implemented as political quota legislation, in the last twenty years. A dramatic increase in female leaders has been experienced as a result, for example in Belgium, women's political representation increased from 12% to 36.7% within a few elections. Success of the gender quota system was also evident in the South African Research Chairs Initiative (SARChI), supported by the National Research Foundation (NRF) of South Africa. Forty-two new chairs have been dedicated to women in South African research institutes and an outcome of positive results were enjoyed, whereby there has been an increase of women role models. This initiative is South Africa's own effort to achieve gender equality in its research institutes. It is a step in the right direction which actually speaks to increasing women's services in these institutes. The same programming and policy principles can be used by South African universities to remedy the low numbers of young women in the STEM fields.

Cummings (2015:8-9) argues that programmes and policies that reduce the gender gap have the potential to increase economic growth in developing countries as well as to significantly improve the standards of living of girls and women. This has a great

impact on the alleviation of poverty, thereby embracing good health and wellbeing. Some of the positive steps towards the achievement of gender parity are as follows:

- Quality methods for data collection, disaggregated in terms of gender, race, ethnicity and socio-economic status, as per validated international indicators; statistical analysis development of a centralized database, where quality and integrity of submitted data is evaluated prior to distribution;
- Research on factors that drive women out of academia, especially in science, technology, engineering, agricultural sciences and mathematics, with identification of contextual factors that inhibit career development, in order to design the appropriate intervention strategies;
- Capacity should be built around the science, technology, engineering, agricultural sciences, and mathematics (STEAM) fields, with the vision to grow the economy of developing countries. The interconnectedness of undergraduate, graduate and postgraduate education as well as the employment life cycle within the STEAM fields should be preserved through holistic interventions, funding and resource allocation.

The British Council (2015:4) recommends that women should be represented in all 'delegations, committees and programmes' and that this should be done in terms of their merit and not for the sake of compliance in terms of gender parity. The Council also suggests that government agencies and international organisations should provide scholarships for women who would like to study in the STEM fields as well as to ensure that they are exposed widely within this sector. What is interesting for this study was the proposal for different mechanisms that would create awareness among women themselves on the programmes that were initiated by the Government of India. The same awareness needs to be created within the South African youth community in general, and to young women in particular, of taking advantage of the programme that has been developed as an outcome of this study, to participate in the STEM fields in bigger numbers for their holistic development.

2.5 STEM EDUCATION FROM APARTHEID TO DEMOCRACY

In constructing and reconstructing sustainable lives for all citizens, South Africa developed new policies after the apartheid era. When compared, South African policies were discovered to be some of the best in the world, according to the research

that had been previously conducted to assess credibility. However, implementation remains a great challenge (The Presidency, 2009:121). I therefore drew the conclusion from this situation, that since the policies have been proven to be good, there may be gaps in their implementation, preventing the intended recipients from benefitting. This research has therefore focused on searching for the root cause by identifying these gaps, i.e. reasons why the number of young women who are studying STEM subjects at HEIs is very low, which continues to widen the gender gap between them and their male counterparts. Based on the findings, an awareness raising programme was developed with an effort to bridge such a gap.

The above-mentioned programme had its base in one of the focus areas for the new government in the post-apartheid era, i.e. to eradicate poverty and inequality among men and women of South Africa. Although poverty had declined slightly at the end of Apartheid, women seemed to be poorer than their male counterparts. Those who lived in rural areas were even more vulnerable than women who lived in urban areas. At the same time, African and coloured women were worse off, relative to Asian and white women. On the other hand, there were more female-headed households than male-headed ones. A large proportion of these women were working as domestic workers and some were employed in low-skilled jobs. The new government had to come up with strategies to close these gaps as soon as possible (Department of Women, 2015:10). The low socioeconomic status of women, and in particular those in rural areas, has a direct impact on access to educational opportunities and even more on opportunities to access quality higher education. This is further impacted on by the inability of the government to recruit well qualified educators to these areas to lay a firm foundation for learners to aspire to follow the STEM fields.

In order to improve access to the STEM fields in particular but education in general, the democratic government of South Africa introduced a number of legislation and policies, in addition to the Constitution of the Republic, Act 106 of 1996. One such piece of legislation is the National Education Policy Act 27 of 1996, to ensure that all deserving citizens of the country have access to the resources allocated for education in an effort to improve and upgrade skills in the country. Whilst the resources were meant to cover the majority of learners, and no longer the few as it was in the past, participation of women in education, particularly in higher education improved.

However, the rate at which male learners passed mathematics, science and technology in Grade 12 remained higher than that of females. This affected the admission of students to those fields in HEIs. These subjects are currently valued more in the workplace and the labour market (ibid: 33, 41).

This report calls for further research into what is happening in high schools, that seems to leave the learners, especially girls, unprepared to become future scientists, technicians, mathematicians and engineers However, the report also serves to inform this study of the anticipated number of young women who would be registering to study the STEM fields at university. Their low pass rate in such fields in Grade 12 precipitates their low numbers in those fields beyond school. The situation would, however, be better if all young women who passed the STEM subjects in Grade 12 would choose careers in those fields, but that is not the case.

The choice of careers in the STEM fields by young women is still a challenge even though the South African government took commendable steps to redress the inequalities of the past in terms of access to education. However, more than twenty years into the new dispensation, the number of women who are passing the STEM subjects in Grade 12 is low as per the abovementioned report. This affects their career choice in such fields at university. There seems to be a lot of work to be done in terms of a needs analysis to try and find out where there are blockages within the education system. Pumping resources for all to access education, only to learn skills that are already over-supplied, creates another challenge of unemployed graduates who cannot plough back into the system that funded their studies and thereby contribute towards the economic growth of their country. This study therefore has focused on increasing the number of young women who are participating in the STEM fields in universities. As stated here, this report calls for further research into what is happening in high schools, that seems to leave the learners, especially girls, unprepared to become future scientists, technicians, mathematicians and engineers.

The sound policies that South Africa is said to be having, is an opportunity for universities in this country to use them to develop programmes that will deliberately empower young women who are students in the STEM fields, those who are professionals in academia, those who have the intention to join these fields as well as

attracting those who did not even think of following them as careers in the first place. This can be done by working together with schools, in preparation for the large STEM fields, female student intake, when girls, as young women enter university.

2.6 ROLE OF UNIVERSITIES IN DEVELOPING STEM FIELDS

Universities are said to form part of the 'Nation's effort to develop a highly skilled workforce for competing in the global economy', with its education providing opportunities for higher salaries, good employment and rapid upward mobility' as economic benefits (World Bank Report, 2009:2). This study seeks to assist young women to acquire these benefits in order to transform their social lives, towards a balanced and sustainable future. For this reason, universities have been selected as the vehicle through which young women will be directed to that position where they will be able to compete in the global economy. Young women, who are already enrolled as students in universities, have an opportunity to use what is offered by these institutions to transform their lives.

In Canadian universities, the number of women enrolled at the undergraduate level was 346,000, almost 40% more than that of their male counterparts, i.e. 246,000. For over a decade, females have maintained the lead over male students. However, women make different discipline choices as compared to males when entering university. The natural science and engineering (NSE) disciplines rank very low as a discipline choice for women, as compared to men. Women outnumber men in most of the non-NSE disciplines and regrettably, the ratio drops off further in the major NSE disciplines (Council of Canada, 2010:9). The percentage of women in these universities is a 58% share of undergraduate enrolment for all fields, whereas the percentage of women choosing the NSE fields is far below that of men (ibid:17–19). Gender equality could be achieved at the NSE bachelor's level if 10% of female undergraduates could be convinced to switch to an NSE field. Furthermore, there is a decline in the share of degrees awarded to females at higher levels of the NSE fields and this becomes worse with regard to doctoral degrees.

In view of the issues mentioned, there is a need to deliberately encourage more women and for the sake of this study, young women, to register in the STEM fields. A greater incentive that would draw more young women in future to STEM fields would

perhaps be when a higher number of women earn doctoral degrees; that could also lead to equity in employment measures.

In trying to curb the persistence of this situation, the Natural Science and Engineering Research Council (NSERC) has implemented a number of initiatives over the past decade to improve the representation of women in the NSE in Canada. One such is the PromoScience programme. Through this, the NSERC provides funding to organizations that are willing to bring science experiences to women and to those that promote interest in science among girls. In 2009–10, the PromoScience budget was $2.8M and 75% of that had a component to increase the participation and promotion of interest of girls in science and engineering. The objectives of the programme are to develop, implement, and communicate strategies to improve the participation of women in the science and engineering fields, as students and professionals, especially to

- encourage female students from elementary to secondary schools to consider careers in science and engineering;
- increase the enrolment of women in undergraduate and graduate programmes in the science and engineering fields in all Canadian universities and colleges;
- increase the profile and retention rate of women in science and engineering employment positions;
- eliminate barriers for women who intend to pursue careers in science and engineering fields;
- promote the integration of female students and professionals within and outside academia;
- provide female role models who are talented, successful and recognized researchers in the science and engineering fields; and
- develop and implement a communication and network strategy, to ensure impact on opportunities for women in science and engineering, at national and regional levels (Council of Canada, 2010:51–52).

These suggestions are activities that universities should be performing if these institutions are aware of the urgency of the development of the STEM fields. Young

women's missing talent should be nurtured by attracting those that are still at school, by adopting such schools and paying regular visits, to secure a large intake for each academic year.

Women professionals in the STEM fields working in universities should also be continuously trained to role-model for female students who are already registered in the STEM. This would also serve as motivation for their retention and the will power for upward mobility to occupy senior position at these institutions. As a result of these activities, including programmes such as mentoring would ensure a cycle of inward movement by young women and retention by older ones into the STEM fields.

The Council of Canada (2010:66) has suggested a number of reasons for female under-representation in the NSE. There is a great deal of gender bias in textbooks and television programmes that do not necessarily depict women as engineers. As a result, as they progress in their journey to obtain a degree, women often feel isolated and somehow intimidated. This naturally affects their level of self-confidence, which ultimately drops. In some cases, the lifestyle of senior female academics is perceived to be that of isolations in their chosen field. In cases like these, universities should counter what is popularised in the national media by deliberately planning programmes that feature conferences and activities where women scientist are actively involved, in order to discourage young women from thinking that they would be isolated in joining the STEM fields. Young women should thus be attracted to pursue the STEM as their career choices.

Maltby *et al*. (2016:3) regard students who are pursuing degrees in the STEM fields as being provided with opportunities for economic empowerment. They find it an even greater opportunity for students who come from disadvantaged populations to turn around their situation. For these authors, such 'first-generation college students', i.e. those whose parents or family members have never attended college (and in this case university) and therefore have no family support due to lack of experience, as well as those from underrepresented minority groups would benefit immensely. One of the reasons is that jobs are readily available most of the time in such fields, which was the case for over the last decade, as found by their research.

In addition, they also emphasize what has been reported numerous times in this study, that workers in the STEM fields earn a higher salary. To relate this situation to South Africa, women are part of vulnerable groups that are prioritised for development because of South Africa's apartheid history and its negative consequences. Young women in South African universities can use the STEM fields to better their situation of gender disparity that brings about desperation in different forms, e.g. poverty, women abuse, unemployment, and so on.

Colleges and universities in the US are reported to be doing their best to attract women and the 'underrepresented minority, in particular the Black, Hispanic and Native American' and first-generation college students to join the STEM disciplines. However, the numbers from these groups are still low in such degrees, 'accounting for only 11% of STEM bachelor's degrees and 6% of enrolled degrees in STEM graduate programs in 2012', as per the National Science Foundation (2015a; 2015b). The reasons for low numbers despite the recruitment is that 'aspiring female scientists and engineers feel isolated', there a few role models and an unfavourable classroom environment (Maltby *et al*., 2016:3). What this study included in its enquiry, is whether universities in South Africa are doing enough to encourage the most vulnerable group, young women in this case, to enrol in higher numbers than previously in the STEM fields. While there are some efforts made here and there, as per the findings, there is still a great need for more work in that regard; hence gender disparity is still a challenge in these fields.

In the article of June 2006, Oloduolo analysed gender differences of students who enrolled in the Faculty of Science at the University of Ilorin, between 1999/2000 and 2003/2004 academic years. When using descriptive statistics to analyse collected data, it was found that the number of female student enrolments was far below that of their male counterparts. A recommendation was then made that the Federal Government should establish compulsory education, which is free for girls up to at least secondary school levels. Another recommendation was that different spheres of government, the National University Commission (NUC), non-governmental organizations (NGOs) and university administrators should organise grants and scholarship awards for female students who enroll for science-based courses, as a way to encourage more of them to study in that field. This recommendation was also

considered for South Africa when comparing the situation in this country and others where this idea was implemented.

Different countries seem to be sharing the sentiment of underrepresentation of young women in the STEM fields and are also making efforts to correct this situation. In their report of 2013, Agu and Omenvi state that an assessment was conducted from 2008 to 2011 at a university in south-east Nigeria, to check the gender status of enrolment into different faculties like arts and science. It was discovered that many higher education courses were still being construed as either masculine or feminine, based on the number of male and female students who registered for those courses. This evidence of the gender gap was needed to sensitize the government, educational institutions and the public in general on how to put in place the necessary interventions (ibid). This research investigated the reasons for the situation in South African universities, which is similar to the university where the above assessment was conducted (in Nigeria) and therefore advocated for programming to close that gap.

Programmes in the form of mentoring by university lecturers are said to be necessary for recruitment as well as the retention of young women in the STEM. According to the investigation conducted by Ramjee, Sibiya and Dreyer (2013), women's enrolment representation in different age groups and at various stages of the actuarial science qualification is very low. They discovered that in 2010, 85% of Fellow members of the Actuarial Society are male and that women represent at least 30% of younger cohorts' student members. The relative performance of female students enrolling for an actuarial science degree at the University of Cape Town was also conducted and the finding revealed that the role of female student entrants has increased over time but their tenacity is lower than that of male students. That presented itself as a need for further research in order to establish the causes for gender disparity and lack of persistence of student entrants to university programmes. The conclusion made was that universities, actuarial science professionals and employers have a role to play to improve the perception of this profession and provide support to female students as well as those who are already working. This research is important for implementation or even further research at the three sampled universities, to investigate if there are similarities with the situation at the University of Cape Town.

The same scenario was discovered when Buabeng, Ampiah and Quarcoo-Nelson (2012) conducted a study which confirmed that the interest of females in physical science should be an issue of international concern. They explained that the number of females who enrolled for other sciences has increased but of all these sciences, physics has particularly low registration. This study investigated whether the female science students of a Ghanaian senior high school would prefer to study physics at university or not and also to establish reasons for their choices. A total of 201 final year female students in four senior high schools offering biology, chemistry and physics in the Cape Coast Metropolis of the Central Region of Ghana, took part in the study. The findings from the study suggest that female students do not prefer physics as a course of study at university level due to limited career opportunities in the subject. The outcome of this investigation was that many students do not have enough information on the careers around physical science. As a result, there is no hope for an improvement in the female enrolment in physics. That leaves physical science educators and departments that are in charge of physics the task of making efforts to create awareness of career opportunities in the study of physics, working together with universities.

Baltodano *et al.* (2012:63) quoted from President Obama's speech of 2009 that America was experiencing a domestic, economic and financial crisis and that the role of higher education was even more critical than before in taking the country out of that situation. The President also pledged federal government's support in the form of leadership development programmes to individuals and in particular women, since he perceived them to be ready to take up leadership positions in higher education. This research therefore observes the role of higher education in transforming the roles that women need to play towards the improvement of economy and poor financial status of a developed country like America. This also implies that higher education and women have roles to play to transform the socioeconomic status of women themselves and of the country at large even in South Africa.

The other reason why South African universities are important in the current study is the fact that young women are already registering in large numbers at such institutions (Department of Women, 2015:43). What still needs to be done is to redirect them from registering in fields that will result in them earning lower salaries, fewer employment

opportunities and where they may not be equipped with the tools to compete in the global markets since their skills would not be scarce and critical or relevant to the needs of the world. Young women should be encouraged to register in large numbers in the STEM fields within the same university at which they have chosen to study. This would enable universities to easily provide the necessary support on the one hand, and the recipients to easily access it on the other hand. In an effort to further enhance enrolment in these fields, a specific fund dedicated to the recruitment of young women in STEM fields, for example the Funza Lushaka bursary scheme for prospective teachers, could be established.

Bursaries, as part of financial resources, are a key element in the fight to attract and keep young women in the STEM fields. According to Maltby *et al.* (2016:3), students who are referred to as first-generation in college are at much higher risk of failing rather than earning their degrees on time. This is caused by a variety of challenges like financial constraints, lack of support from parents and lack of good high school/college transitional preparation. That results in only 28% of these students passing their 4-year bachelor's degree, as compared to 42% of students who had at least one parent who had attended college. The introduction of the National Survey on Living-Learning Programs (NSLLP) contributed positively and bore good results. The Living-Learning Communities (LLCs) are programmes that allow undergraduate students to live together in the same residence and participate in 'academic and/or extracurricular programming designed especially for them'. The lesson that I learnt from the above scenario was to ascertain whether universities have financial support programmes specifically for women. With the statistics of young women in the STEM disciplines at South African universities presently, it was evident that students need more than that currently offered. As per the above report, students perform better when they are supported through programmes that are specifically intended for and cater for their individual needs. What was even clearer to me was the fact that, with support from their fellow students, they develop a sense of belonging, which motivates and bears good results. These two aspects were embraced during the development of a programme, as an outcome of my study.

Programmes that keep the numbers of both young women and young men at the same level need to be implemented at university level, as per the following report. In US high

schools, girls and boys are said to be taking up mathematics and science courses in almost the same numbers. And the results of a standardized test suggested that high school girls are as ready to pursue science and engineering careers in college as boys are. However, right from their first year in college, young men's numbers are higher than their female counterparts and young women are most unlikely to choose careers in the STEM fields. This means that at college level, the gender disparity is wider than at high school. Having observed this trend, the (then) President of Harvard University, Larry Summers, delivered a 'controversial speech', suggesting three hypotheses for this underrepresentation of women in the STEM: 'Different innate aptitudes among men and women at the high end of science-based fields; different career-related preferences among men and women, and discrimination'. There is, however, escalating evidence against the aptitude-based hypothesis as reported. It is also difficult to blame discrimination as there is no proof of that. The remaining hypothesis could be preference, which also needs to be tested (Reubena *et al*., 2014:403).

Although these authors seem to be ruling out discrimination, I disagree with them, based on the situation in this country as a result of the apartheid system of government. A study was conducted by UNICEF in South Africa on the attendance of school by girls and it was discovered that some girls who come from indigent families absent themselves from schools at least four days every month when they have their monthly periods because of lack of sanitary towels. Awareness campaigns on this subject have only recently been undertaken. As a result, such girls face discrimination by the system because of their biological make-up since whether they are at school or not, teaching and learning takes place and even schools do not have a specific catch- up programme for them. As a result, boys tend to excel in such situations because they are more consistent in school attendance and do not miss any lessons as girls do.

Female students at universities should be provided with support in order to address problems in their pursuit of science career training, before, during and after their undergraduate education. That was recommended in the report of an article written by Erwin and Maurutto (1998:51) on how to improve the enrolment of young women to become higher than that of young men at a large, urban university in Canada. However, the number of young women got 'dramatically lower' in the science career

fields. Although young women had not accounted or interpreted that to these authors' knowledge, this report has their responses on what influenced their career choices. Its findings revealed the importance of the role played by subjectivities which were produced, understood and acted upon in that regard. The evidence achieved was that women find it difficult to compete and negotiate their identity in the STEM fields. Therefore, universities should intervene to establish the reasons why young women cannot find their place in the STEM fields.

Universities as research institutions are better placed to find out what influences the choice of careers of young women. In fact, sufficient research has been conducted and it has been discovered that universities need to support young women in the STEM fields in order to increase their participation in these institutions. This study has contributed to that research by identifying specific areas and ways in which universities can support young women, i.e. through women-specific programmes like the product of this research. Young women therefore played a bigger role in informing the programme that I have developed by providing ways in which they can best be supported in order to can level the playing fields in a way that will enable them, not only full access into the STEM fields but also retention and growth within that sector.

Lack of retention and growth in the STEM fields add to the bigger challenge of a significantly low number of young women who are choosing careers in these fields. Erwin and Maurutto (1998:52) have also confirmed that the number of women in the science and technology fields decreases with higher levels of education and that numbers are further decreased in the applied sciences and technical fields. Instead, a large number of women were found in the social and medical sciences, where there was low status, low salaries and less job security. Where the study was conducted, in North America, it was found that women were fewer than 30% in physical sciences and mathematics undergraduate degrees, only 18% were studying engineering and 30% were at doctorate level in physical sciences and mathematics. The most disappointing fact was that even those who held such degrees would not at any stage occupy professional positions or work in scientific fields.

These findings shed great light on this study, to also include the element of retention while focusing basically on recruitment. There will be no benefit if large numbers of

young women are successfully recruited to register and study the STEM disciplines only to have them working in the social sciences with all those acquired skills. As a result, the outcome of this study describes how young women could be retained in the STEM fields as future role models, academics who will continuously conduct research to keep up with the changes in the field and also as policy developers who will ensure that the emerging changes are legally captured and actually implemented. This implies that the developed programme will also need to be amended occasionally, depending on the changes that would have emerged in the STEM fields. What was also taken into consideration was to include strategies that would enable young women and women in general to stay in the STEM system by studying further in the same fields and for that matter work as academics and professionals in such fields.

Universities have a duty to prepare young women who are students and those who are professionals to meet its expectations of them and also check what are their own expectations of these institutions, as a measure to cultivate the land for ploughing for good returns. Young women seem to be entering universities with cards lined up to start planning, not only their academic lives and careers, but also establishing their families. The question is whether universities are ready to accommodate and address these expectations and provide the necessary support from the beginning to the end of their study time in these institutions. Ledwith and Manfredi (2000:20) wrote an article on women's position in higher education in Europe and compared this with a case study analysis of senior women at a certain 'new university' in the UK. A younger woman who was participating in the research, spaced out her maternity leave among the three children she intended to have in such a way that these leave periods would be granted by three different employers as she climbed her career ladder. She referred to it as 'balancing the act'. On the other hand, senior women appreciated the latest support granted in the form of paid childcare and post-feminist expectation rights on career equality about young women found in other studies.

Preparation for students and young women for studying at a university should start when they are still at high schools. Universities should therefore partner with high schools to feed them on the trends that first-year university students, fresh from high schools, present and how those may be addressed as part of induction for such students. As the same time, on arrival, there is a need to determine if a smooth

transitional reception of new students is in place, particularly for young women into the STEM fields at universities since challenges have already been identified. The mechanisms of bridging the gap between what the Curriculum Assessment Policy Statements (CAPS) has provided as a foundation in these subjects and the complexities to be experienced by the first-year students should be firmly in place. If the answer is positive, it would mean that if young women continue to avoid the STEM fields, the challenge would be lying outside the institutions elsewhere. Further research would then still be necessary to root out this challenge wherever it is hiding.

2.7 STATISTICS OF YOUNG WOMEN IN STEM FIELDS GLOBALLY

The United Nations Development Programme's (UNDP) Human Development Index contains statistics of women in higher education. This report states that women have the tendency to be overrepresented in the 'lower-level', 'soft disciplines' and short-term tertiary education. It further reports that the number of women at universities is higher than that of men in many countries globally. However, women in such countries tend to leave tertiary education at lower levels. What is more important for this study is the aspect of the report noting that women are under-represented in the technical fields and natural sciences. The unfortunate reality is that such fields offer 'well-paid' and 'high-status' jobs (Tjomsland, 2009:411–14). South Africa is also reported to be one of those countries, as emphasized by the Department of Women (2015:3). The overrepresentation in the 'lower-level', 'soft disciplines' and short-term tertiary education might be influenced by the notion that these are easy quick gains that will enable young women to secure a career and continue with their lives or in some instances the responsibility to turn around the family fortunes, economic status and cater for siblings.

If women do not participate in the disciplines that offer good salaries and high-status job opportunities, their socioeconomic status will remain poor and unchanged. They might not be able to keep up with the forever rising inflation rate. They may have to remain poor or dependent on their male counterparts, as their employees and wives to uplift them socially and economically, which works to their disadvantage since it results in gender disparity in those areas of their lives. This might also be one of the reasons why certain jobs are still male-dominated, hindering women's way towards complete transformation. Based on the above reports, this research needed to

investigate the main reasons for these results and advise accordingly through an awareness programme, in order to enable women, especially young women, to be free of that situation.

In almost the same situation, a survey of the performance of 5000 undergraduate students' in the science subjects was conducted in the US (Erwin & Maurutto, 1998). It was found that the ability and performance developed in the first and second years in engineering, biological sciences, physics and chemistry was evidently the main cause of interest and persistence in these fields. However, 52% of female as against 44% of male students significantly dropped out of the computer science and mathematics fields. This aspect focused on whether gender plays a role in women's ability to perform in the science and mathematics fields. The findings were inconclusive and contradictory in the sense that in some cases men performed better than women and in others women did better than men in these subjects, even with less background preparation. In other studies, ability was developed in terms of courses in mathematics and science to build a good background, supported by good test scores and aptitude test results. However, gender did not seem to have had any influence in the choice of careers (Erwin & Maurutto, 1998:53).

This finding suggests that women's academic performance has nothing to do with them dropping out from the science fields. One study also found out that high-performing female students are those likely to persist in postgraduate studies (Erwin & Maurutto, 1998:53–54). In 1952 in an effort to prevent this from happening, the Society of Women Engineers (SWE) was established in the US, followed by the Federal Civil Rights Act of 1964 whose aim was to protect the rights of women engineers in the workplace. Women started to register for degrees in engineering, drawing from the support and protection they were guaranteed.

However, despite all these measures and many other subsequent efforts, in 2006 women represented 56% of students in a four-year institution but only 17% of them were engineer graduates (Ureksoy, 2011:1–3). While this report was mainly concerned with engineering, the current study has engineering as one of the fields researched. As the researcher, I was also interested in the support that women started to receive from the birth of the SWE and many more efforts to preserve their stay and

increase in the technical fields, which prevailed for some time. My undertaking in the light of these findings is that women may be attracted to register in large numbers in the STEM fields. However, it is equally important to see them through the graduation, post-graduation and occupation stages. Whatever happened between 1952 and 2006 must have led to the results presented above. The issue of retention through motivation and incentives is somehow glaring and therefore needs to be carried over in the effort to improve participation in the STEM studies.

The 2011 report by the Economics and Statistics Administration of the US Department of Commerce states that women have been underrepresented in the STEM fields for a number of decades and presented the following as some of the disadvantages of the above situation:

- Women with STEM jobs earned 33% more than those in comparable jobs in the non-STEM jobs.
- Although women comprise 44% of the workforce in the US, they were holding just 24% of STEM jobs, and in engineering they occupied less than 15%.
- Women with STEM degrees were less likely to work in those fields than men (Jakes, 2013:2).

The importance of this study was to highlight that gender parity contributes to innovation in all study fields and that gender diversity is necessary in the workplace as it is recognized as a positive goal for the global workforce on a large scale through development and the education system. The introduction and enforcement of employment equity dispensation should also be prioritised by the Department of Labour and employers. Gender equity in the workplace can result in the improvement of self-esteem of individuals since it brings about equitable salaries and increased opportunities for men and women as well as for their families.

Jakes (2013:6-7) also reported that a number of studies conducted show that college degrees are linked to social and economic benefits and enhance the quality of life of individuals, their communities and society as well as the present and future generations. Higher level education can result in members of society demanding fewer social services such as welfare because when individuals have skills, they are able to

make decisions on the kind of lifestyles they want to lead, including health care, as well as how to use their finances. Therefore, high representations in the STEM fields could mean fewer demands of services from the state.

The underrepresentation of young women in STEM fields and its relationship with mathematics presents itself in different ways. Another example is that of the small number of doctorates that are awarded to women on an annual basis. The report from the National Science Foundation's National Center for Science and Engineering Statistics (2013) states that out of nearly 51 000 doctorates awarded in 2012, 46.2% were awarded to women. On the other hand, the percentages of degrees awarded to women in the social sciences, education, and humanities, were 58.2%, 68.7% and 51.8% respectively. However, the percentage of females earning doctorates in the life sciences, physical sciences (including mathematics), and engineering were 55.7%, 28.5%, and 22.4% respectively. A further breakdown of the physical sciences presented percentages obtained in chemistry, computer science, geosciences, physics-astronomy and mathematics as 37.1%, 20.6%, 41.0%, 20.9%, and 28.3% for doctoral degrees earned by women respectively during 2012 (Beekman & Ober, 2014:35–36).

Women are indeed underrepresented in the STEM fields but in particular, at the higher levels of these fields. One exciting, specific intention of the Staffing South Africa's Universities Framework (SSAUF) is to identify and nurture newly recruited academics by aligning them with the upward mobility pathway within the academic sphere, by providing support towards the achievement of masters' and doctoral degrees in their chosen fields. This would address a concern that women are underrepresented in senior academic positions, constituting below one third of staff, i.e. 29.5% (DHET, 2015:7–8). Encouraging is also the fact that support will be provided in the final year/s of undergraduate level and shortly at postgraduate level. This development is expected to enhance teaching expertise and research skills, as well as scientific publication skills. However, continuous professional development opportunities will continue to be provided to all academic staff at all levels, for sustainability. In addition, teaching and research will be strengthened by easing the pressure through the recruitment of supplementary staff at all universities (DHET, 2015:6).

The previous paragraph presents a plan that I have embraced in the programme developed in chapter six of this study, i.e. ensuring that young women who have pursued careers in the STEM fields and those who would be recruited and attracted through the programme, will be supported and enabled to acquire senior degrees (master's and doctoral) in the same fields. This should resolve the challenge mentioned by Beekman and Ober (2014:35–36), that most women who have chosen STEM field careers often fail to pursue their studies for a senior degree and instead leave these fields. However, I feel that there should be a deliberate effort to develop more women-specific programmes, and resources towards their implementation should be shared among stakeholders. Furthermore, research, ring-fenced funding and support initiatives must be used to strengthen the existing relevant programmes and institutions as well as advocacy to turn the situation around and increase the number of young women in the STEM, firstly as students but ultimately as the active workforce and professionals in these fields.

According to Professionals Australia [Sa], in Australia in 2011 only 28% of qualified employees in the STEM fields' workforce, aged 15 years and above were female against the 55% of females in all fields in the tertiary qualified population. In the engineering and technologically related fields in particular, the numbers were 14% for females and 86% for males. For information technology, it was 25% for females and 75% for males. The least disparity was in the natural and physical sciences where females occupied 47% of the workforce against 53% of males. In addition to that, women's representation in the STEM undergraduate degrees is significantly low. The completion rate was slightly higher than that of the Organisation for Economic Cooperation and Development (OECD) average of 30% for 2011 as 33% of tertiary qualifications were awarded to Australian women in STEM fields. This is a very low number, after decades of making efforts to improve the participation of women in the STEM fields. It lays a weak future workforce foundation and lack of gender equality in these fields.

For the US, Noonan (2017:1) reported that in 2015, women occupied 47% of all jobs in the workforce but only 24% of those were jobs in the STEM fields. The same scenario also exists at tertiary institutions whereby women constitute slightly more than half of the college professionals but make up only 25% of the college professional

in the STEM fields. However, women who were working in the STEM fields were earning 35% more than comparable women working in the non-STEM fields. In addition, women with the STEM jobs were also earning 40% more than men who were working in the non-STEM jobs. Unfortunately, women make up only about 30% of all graduates in the STEM fields. In engineering, women make up an even lower share of degree holders in all STEM fields. A more depressing situation is that women with STEM degrees are less likely to work in these fields than their male counterparts. Instead, they are more likely to work in education or health care, despite their qualifications in the STEM.

Noonan (2017:4) designed a table, indicating US employment in STEM occupations, between the years 2009 and 2015 as shown in Table 1.

Table 1: Noonan's outline of STEM employment occupations

	Male 2009	**Male 2015**	**Female 2009**	**Female 2015**	**Female percent 2009**	**Female percent 2015**
STEM total	5,640	6,520	1,790	2,100	24%	24%
Computer Science and Maths	2,534	3,162	929	1,101	27%	26%
Engineering	2,079	2,195	330	364	14%	14%
Physical and Life Sciences	553	595	374	448	40%	43%
STEM managers	474	568	157	187	25%	25%

The picture in Table 1 is not a good reflection for the STEM fields, where the number of women should be increasing, instead it remains as it was or is even deteriorating. The overall results show that women's percentage in the years 2009 and 2015 is the same, meaning that there was no improvement in the participation of women in the STEM fields in general. The same situation occurred in the engineering field and for women as STEM managers, where there was no improvement at all. A deterioration

of 1% occurred in computer science and mathematics, as well as an increase of 3% in physical and life sciences.

2.8 ENVIRONMENTAL EXPERIENCES OF YOUNG WOMEN IN STEM FIELDS

One of the most encouraging findings of the OECD report of 2006 is that Canadian young women whose mothers possess university qualifications are 71.5% likely to participate in university education and those whose fathers are university qualified, are 58.8% likely to engage in university education (Auston & MacPhail, 2011:149). This trend gave rise to a question to this study: 'Could it be that most young women in South African universities are likely to choose careers in the fields where their mothers have a qualification?' If the answer is positive, this might be the reason why the STEM fields are mostly occupied by men, considering the history of this country where one of the triple oppressors of women was gender, in the sense that there were jobs for men and jobs for women (Department of Women, 2015:5).

The other interesting finding of the OECD study was that Canadian young women may also be attracted to secure a degree-level qualification in a range of fields based on the location and cost advantages that colleges offer in comparison with universities (Auston & MacPhail, 2011:53). In other words, the place where a university or a college is based and the cost of the college against that of a university were determining factors for the choice of a career by some young women. Having used those criteria, it would then mean that an individual might be forced to choose from what the college or university offers and not choose out of interest.

The Interests and Recruitment in Science (IRIS) project is the European Seventh Framework Project, which focuses on the challenge that only a few young women choose education and a career in science and technology. The project therefore aims at the improvement of recruitment, retention and gender equity patterns in higher education.

To acquire information on what influences the choice of a career by young people, the IRIS Consortium developed a questionnaire based on the model of achievement-related choices and on the theory of the role of self-efficacy beliefs. A total of 3,680 Australian first-year biology students provided information on the factors hindering

education choice. The findings revealed that experiences in secondary school and good teachers influence the choice of STEM subjects. The project also highlighted a significant finding, namely that good teachers are one of the key influencers on the choice of STEM studies of their learners. However, most importantly is the fact that in both countries, Canada and Australia, females were more likely to be influenced by a third person, such as a sister, brother, father and mother in comparison with male students, in terms of the value factor. In both countries, the expectation of success factor was significantly higher in males than in female students. All in all, good teachers and great interest in STEM subjects determine the choice of careers in these fields (Elster, 2014:57–58).

This country also needs teachers who are well trained in the STEM fields and master the subject content, accompanied by well-resourced laboratories, which is still a challenge in some schools. There is also necessity to strengthen career guidance as a component of the subject Life Orientation in schools, especially from Grades 8 and 9. That came as a strong recommendation for the improvement of young women in the STEM fields. Since this recommendation seemed to be the formula that might trigger learners' interest in choosing the STEM subjects from Grade 10 to Grade 12 and also take them up as careers at universities, this study acknowledged that and advocated, as part of its outcome, for high schools to conduct communal teaching among themselves. The role that parents and family members play to influence students and in particular young women in the choice of careers has been embraced as well. Because some families have been challenged with the scourge of HIV/AIDS, leaving some young women as head of the family, such families also need specialised support that should be dealt with appropriately.

In a case that is familiar to the one in the previous paragraph, Hazari *et al*. (2017:1) reported on the effect of peers' interest in high school biology, chemistry and physics classes on students' STEM-related career intentions and course achievement. These authors defined an interest quorum as a science class where students recognised a high level of interest for the subject matter in their classmates. They also hypothesized that students who experience such an interest quorum were most likely to choose a STEM career. The effect of five levels of peer interest reported in biology, chemistry and physics courses on students' STEM career intentions were compared, based on

data collected for a national survey of students' experiences in high school science. The results were positive, confirming the 'effect of an interest quorum even after controlling for differences between students that pose competing hypotheses such as previous STEM career interest, academic achievement, family support for mathematics and science and gender'. The effects of interest quorums based on good performance were also evident but to a smaller degree. More importantly was the emphasis presented, of interest quorums for creating classroom environments that increase students' intentions toward STEM careers, despite controlling the difference in the quality of teaching.

While creative classroom environments may stimulate the intention to take up a STEM career among fellow students, the enhancement of such intentions is still a challenge for young women. Since the purpose of the study above was not necessarily to inspire female students but students in general, this study had to find strategies of using creative classroom environments towards addressing gender stereotypes and disparities in the STEM fields, which are detrimental to young women. I used competing hypotheses of culture/tradition, feminism, classism, etc. as a test, in order to present a responsive programme towards gender equity in the STEM fields, for the socioeconomic sustainability of young women.

Erwin and Maurutto (1998:54) argue that a number of studies have found that socio-psychological factors have a great influence in women's choice of science careers. Self-esteem and self-confidence in mathematics and science are said to be playing a bigger role, from junior to senior schooling as well as influencing their career choices. Some studies show that most women have lower confidence in these subjects than men and are also likely to perceive their aptitude in these subjects to be low. This underestimation and negative self-concept in the sciences is often linked to women's traditional gender roles, socialisation and the perception that they had no affinity with science as a subject.

On the other hand, cultural tensions and structural obstructions that only women encounter are said to be eradicating interest and aspirations that are evident in female undergraduates. This is also emphasized by a perception that science and family do not match and that the female identity is incompatible with the scientific identity. In this

case, there is a need for female science undergraduate students to have mentors in these fields and also be provided with the necessary support from peers and role models to persist in their studies. Universities therefore play a major role in ensuring that the above environment prevails and barriers are removed.

Barriers such as women's academic culture and structures have been identified as other factors that contribute towards their choice of careers towards or away from the science fields. The male-dominated discussions and lack of female role models within science education are cultural and instructional activities that seem to bring the perception that female students' performance in the sciences is poor. The environment around the science fields has a male bias and makes women feel excluded. As a result, women lose interest and their initial aspiration to pursue a career in these fields (Erwin & Maurutto, 1998:54–5).

In another study, these authors showed that because there are very few women in the scientific fields they are not regarded as a normal recruitment target. Women themselves do not think they are an important part of the science programme, as a result of this tendency. Therefore, recommendations emanating from the above studies suggest that women need to be given sufficient support in order that their numbers in the science fields are increased to balance those of their male counterparts. A holistic approach is recommended, in terms of policy inclusion in all faculty departments within universities, from childcare to recruitment and retention, as well as credit for mentoring, to mention a few. While these recommendations were made, the authors were concerned that in most of the above studies, an important aspect of the research was missing, i.e. the standpoint of women themselves; how they evaluate and perceive their abilities, experiences, environment through their undergraduate studies. As a result, they engaged young women from a university in Canada who were undergraduates and those who had quit the science fields (Erwin & Maurutto, 1998:54–5).

Talking to women and making them aware of not only their potential but also their role in the STEM fields, is important and needs to be formalised through programming. The following discussion formed a foundation in understanding young women's flooding of social fields even before data was collected for this study. In her doctoral thesis

(2011:1–2), Ureksoy reports that the STEM careers are male dominated, and historically characterised as such. On the other hand, women tend to be attracted to the fields and occupations that provide an opportunity for social interaction and allow an individual to play a useful role in society, like education and health care. Careers in engineering, for example were regarded as male-designed since they are more hands-on and perceived to be unsuitable for women due to their dangerous conditions and physically strenuous nature. This author also emphasised that attracting women but also retaining them in the male-dominated careers has been a challenge for some time. She reported that when asking some women who were already in the STEM fields about their future plans, some talked about leaving the field or even confessed that they wished they had not chosen the specific field in the first place.

Ureksoy (2011:1–2) also reported that since the beginning of the 20th century, women who were working in engineering fields were perceived to be against the traditional norms, which was encouraging boys and not girls to join these fields. She reported that women were first encouraged to join the engineering field during the Second World War, when there was a great shortage of men to perform such duties. Women were trained only to do the work but they were not encouraged to study for such careers at a university. Those who registered in the fields met with resistance that women are not supposed to study in technical fields. As a result, a number of support groups emerged, e.g. the Society of Women Engineers (SWE), formed in 1952 and still active in providing support to, and advocating for, women engineers to date.

Support structures need to be established by schools, especially for the small number of girls who pass Grade 12 in comparison with boys as reported previously. What Jakes (2013:55–7) alludes to is that good teachers and the inspirational quality of the school environment, outreach programmes with enriching activities, sports and role models are said to be playing a major role in influencing student choices for college majors and subsequent careers after school. A supportive family and its level of economy have also been found to add value to the choices made for a future career.

The report also referred to studies showing that often young women who are top achievers in mathematics do not necessarily pursue a STEM career. Seemingly, interest in an occupation is influenced by several factors which include the self-

confidence of an individual and the ability to succeed in that occupation, the perception of gender roles according to the cultural norms of the individual's society and its belief systems as well as the personal values of those who make career choices.

Besecke and Reilly (2006:4–6) identified factors influencing women's initial career choices. The common ones are, among others, parental support, peer group pressure, the quality of teachers, exposure to career paths, counsellors and individual interests. However, 'the role of early enriching experiences, mentorship programmes and relationships resulted in a positive influence on women's choices and success in the STEM fields, considering the pattern of women's enrolment in those careers.' These authors also identified three key factors which influence women's initial career choice of a scientific field, as follows:

- Early opportunities should be given to girls in order to develop exposure to and confidence in their abilities to engage in science-related activities.
- Myths and misconceptions of the activities involved in science and science careers should be avoided and clarified.
- An open-mind in and towards science and scientists should be the order of the day.

Jakes (2013:58) added to the three, namely, that classroom activities should provide opportunities for hands-on experiment, role models and mentors, special motivation, and opportunities to meet and have contact with scientists, in order to see the interactive process of scientific exploration and discovery.

According to Professionals Australia ([Sa] 6–7), women scientists leave the profession in greater numbers than their male counterparts. One of the main reasons for that situation is the difficulty that women experience in balancing family and career responsibilities. The Australian government's Innovation Agenda acknowledges the fact that some women invest in education up to PhD level and then leave the profession because of barriers, preventing them from balancing family and career responsibilities. This is a challenge that needs new models of work flexibility, allowing women and men to better manage and reconcile their scientific research careers with family responsibilities. The advantage of this initiative is not only addressing the issues

of equity and justice but it is also a matter of economics, vital in relation to the labour market demand and supply. The labour market needs the talent pool of professionals in the STEM fields, i.e. engineers, scientists, IT specialists, etc. There is also a need for continuous improvement of quality, diversity and output of the STEM research, innovation and productivity strategies.

The following are some of the strategies proposed and commitments of the Australian Professionals to remedy the situation of underrepresentation of women in the STEM fields, in their exact words:

- providing STEM role models at primary and secondary school levels;
- increasing the number of girls undertaking STEM subjects in their final years at secondary school;
- helping address unconscious bias at the level of workplace recruitment and in promotion practices;
- providing workplace flexibility to support balancing work and family responsibilities;
- addressing workforce cultural issues which may tolerate discrimination, sexual harassment and bullying;
- ensuring access to continuing professional development (CPD) regardless of employment status;
- reviewing the value attached to occupations and industries which have a high proportion of females;
- providing positive role models for women and change champions in management and leadership positions;
- rewarding and recognising strategies and career pathways which address both career aspirations and the need for flexibility for those working in STEM fields (ibid.).

The Australian Professionals is one example of a support group that not only preaches about increasing the participation of women in the STEM fields but also actively takes steps to implement measures. This serves as a good practice and lesson that needs to be taken by South African professionals, especially those at universities, to implement programmes that will enable and support young women to take up careers in the STEM fields in large numbers and that those women who are already

professionally trained stay in these fields and become mentors and role-models for young people as well as researchers who will conduct further studies for future innovations.

According to the British Council (2015:5), Professor John Perkins' Review of Engineering Skills was one of the major studies conducted in the United Kingdom that reviewed the provision of engineering skills in the country. The main issue highlighted was the lack of diversity in engineering education and careers. According to this review, the UK has the lowest number of female engineers in the European Union, i.e. for every ten engineering professionals, only one is a woman. The review also suggested that funds should be made available by employers in order to support women engineers who want to return after a career break.

The need for support of women scientists in general, in their different disciplines within the STEM fields is essential. Women scientists have almost the same challenges worldwide, even if their activities are not identical. They almost all operate in a chilled environment and find themselves isolated in an environment dominated by men, who do not necessarily share their roles as mothers and basic child care-givers at home but share the same space in the workplace. The research conducted is evidence that with more support, women retain their positions but with no support, the reaction is different. As a result, provision of the relevant support, according to the needs of individual scenarios, should form part of all programmes that have the intention to improve the participation of women and young women in the STEM fields.

2.9 CULTURE AND TRADITION

Reubena *et al*. (2014:403) designed an experiment to isolate the potential effect of discrimination in order to determine whether it contributes to the low percentage of women in mathematics and science careers. What they discovered was that when job applications are processed, the best candidate is appointed if the candidate's personal information is unknown. However, in the case where candidates appear for an interview, men are twice more likely to be hired for a mathematical task than women. On the other hand, should candidates self-report their ability to perform such a task, women are still discriminated against, since men have the tendency to over-report by boasting about their performance; most employers fall for this ploy. These authors also

report that discrimination can only be reduced but not completely eliminated if full background information on the performance of candidates is provided. This is the outcome of the Implicit Association Test, indicating that implicit stereotypes predict 'the initial bias in beliefs' as well as the 'suboptimal updating of gender-related expectations', if participants self-report their performance.

The above report presents an element of patriarchy, symbolising the STEM fields as made for men, i.e. if there are two candidates for a maths-related post, a man and a woman, then the man's appearance automatically secures him the post. At the same time the report also highlights the feelings of superiority that are normally displayed in patriarchal communities, where men unnecessarily overrate themselves and regard women as second-hand citizens, as happened during the above investigation. This is evidence enough that stereotypes affect the choice of careers of women, away from the STEM fields. The over-reporting of performance by men seems to have such men's confidence built in their make-up. Women, on the other hand, may feel discouraged from joining the STEM fields, based on experiences like the one above. This attitude justifies the need for women-specific programmes that will encourage and motivate women to take up careers in the STEM fields.

The origin of the attitude referred to here may be anchored in the more patriarchal societies, where men are regarded as natural managers of subjects such as technology, science and business (Tjomsland, 2009:413). Therefore, more men than women are taking up careers in those fields. Such men often have full access to higher education and take up uncontested jobs as they are perceived to be taking care of their families and serving society as the main source of the labour market. That creates a gap between men and women, depending on the severity of practice in different countries and regions. It also has a great impact on women's access to higher education globally, although the practice is at local level.

Lack of access to education, and in particular STEM education, is a challenge shaped by negative socialisation, in the name of culture and tradition. In a normal, black South African family, a girl is expected to help with the household chores of cleaning up and cooking for the family whilst boys will be washing the car and help to clean the yard, activities that occur once in a while and not on a daily basis. In these cases, girls spend

more time working at home while boys may use that time to study and catch up with school work. These issues contribute to girls' choice of careers as they tend to choose what they are familiar with, i.e. taking care of other people, hence teaching and nursing become the automatic choices for many girls. They are also believed to lack skill in mathematics and science, simply because they are women. In that sense, young women are denied full access to education.

Access to higher education for young women in the Arab countries is reported to be based, not on the choice of career or ability to compete in the economic market. Instead, young women access higher education to gain status and for prestige, enabling them to compete in the marriage market. On the other hand, sub-Saharan African countries are known for the cultural practice of regarding the awarding of a higher degree as a disadvantage to woman and not proper for a wife (Tjomsland, 2009:413–14). These practices are an indication that in some countries higher education is taboo for young women, let alone the technology and science subjects which have been assigned a masculine nature. This and related practices that make higher education inaccessible for young women actually place men as income generators and therefore as authorities over women both economically and socially. In such cases, women depend on the income generated by men, which also puts them at the mercy of their husbands. This factor adds to the causes of women's lack of socioeconomic transformation.

The potential socioeconomic transformation of women and in particular young women seems to be a far-fetched reality if the above gender gaps are not closed. I have noted with understanding, the role of culture as one aspect prohibiting, not only women's access to higher education as is evident in the above-mentioned cases but also access to certain subjects. Access to the STEM fields as career choices for young women is even more obscured by the belief that only men are natural managers of such fields, hence I felt there was a need for a contribution of an awareness programme in this research.

Whilst most of the authors mentioned in this study seem to be disturbed by the small number of women who are taking up studies and careers in the STEM fields and the need to improve that situation, Nqamane (2009:156) reports that in sub-Saharan

Africa, women's numbers are said to be increasing in the jobs that have a low salary, e.g. in the agricultural field. As Satyanarayana and Meduri (1982:2–3) warn, social resistance arising out of stereotypes, fears and misconceptions that education might alienate girls from traditions, social values leading to maladjustment, conflicts and non-conformism, need to be rooted out of the minds of individuals.

The stereotypes in socialisation are also evident in the survey conducted by Satyanarayana and Meduri (1982:2–3), on the general indifference to the education of girls. When sourcing for reasons for the educational backwardness of girls and women from the learners, the following were some of the responses they provided:

- Early marriage and social inhibitions against girls who are pursuing education after marriage;
- In some cases, girls become victims of child labour, especially if they come from impoverished backgrounds and the hard, domestic chores which are said to be girls' responsibilities and they are required to perform even if they are not married;
- Beliefs that the sole occupation of women is to bear children, to take care of her husband and children, in addition to some general domestic work;
- Discrimination against women in the labour market, both organized and unorganized sectors, especially regarding recruitment, training and development, as well as promotion;
- Some girls and their parents find that the school curriculum does not conform adequately to their needs and interests;
- Unsuitable school hours and inflexible social timings;
- Facilities for girls in some schools, particularly in the mixed gender schools, are found to be inadequate.

The harmful gender stereotypes that are used by women oppressors, in the name of culture and tradition, should be rooted out in the communities through education, formal and informal. Universities could use the curriculum to integrate gender-sensitive information and activities and also train lecturers, the deliverers of that curriculum, to lay a sound foundation, in an effort to destroy the myth that the STEM fields are meant

for men and not for women. This would attract more young women into these fields and increase their representation in all spheres in the STEM sector.

Cummings (2015:7) quoted the World Bank Report of 2012, that women represent 40% of the world's workforce, 43% of the world's agricultural labour force and more than half of the world's university students. However, women have merely 1% of the world's wealth. That is, despite all the efforts made to promote gender equality and to close the gender gap in the world's workforce in the past 50 years. Regrettably, much of women's work is still in the sex-stereotyped occupations and is more poorly paid than men's. As a result, women are extremely affected by the financial and economic crisis globally than their male counterparts. However, women are said to be more likely than men to take money back into their families and communities, as well as to drive economic growth and social progress.

2.10 PARTICIPATION OF YOUNG WOMEN IN STEM FIELDS IN SOUTH AFRICA

According to the Department of Women (2015:5), before the dawn of the democratic government in South Africa, most women were subjected to 'triple oppression' in the form of gender, race and class inequalities, e.g. most black women were in low-skill jobs as domestic workers. On the other hand, the labour market had been dominated by men. Those who were traditionalists and believed in a patriarchal society were encouraging that situation; hence in some communities it was not important for girls to attend school. This situation was made worse by the apartheid system which excluded blacks in general from educational opportunities, including freedom to choose certain subjects, in an effort to use them as a pool of unskilled labour (ibid.: 33).

To correct this situation, the democratic South Africa ratified a number of legal instruments that were advocating the promotion and protection of women's rights, to ensure that women, including young women, are developed and empowered politically, socially and economically. Instruments such as the National Education Policy Act (NEPA), Act 27 of 1996, the South African Schools Act (SASA), Act 84 of 1996 etc., were meant to assist the country to transform the education system and enable access to education by all. The Constitution of the Republic of South Africa,

Act 108 of 1996 itself was developed to ensure that all citizens receive among others, education of their choice, irrespective of their gender, race and class (Department of Women, 2015:33). Based on this, my conclusion is that South Africa needs a youth community that is well balanced in terms of socioeconomic skills, to ensure a smooth take-up of the future by young women and men who are fully empowered and ready to take the country to the next economic level.

On the other hand, the government has also proposed programmes and initiatives such as Techno Girl (by the Departments of Basic Education and Women and UWESO Consulting) as well as those that are based in the Department of Science and Technology, i.e. Academy of Science in South Africa (ASSAF), The Science, Engineering and Technology for Women and the National Advisory Council on Innovation, to ensure that girls and young women are not only encouraged but also assisted to take up subjects and careers in the STEM fields.

There is a demand for STEM graduates in workplaces in South Africa since a science-based innovation is regarded as a big economic driver in the country. Unfortunately, many women are not choosing these fields. In 2012 women constituted 79.3%, 73.8% and 73.7% in the education, health and welfare fields, respectively which are referred to as gender-defined fields. Even in the health sector, women graduate in large numbers as nurses and health care workers, not in the higher degree specialisation areas (Department of Women, 2015:43). The low percentages of women STEM graduates (28,5%) in engineering, manufacturing and construction has prompted the government to set guidelines to improve the distribution of bursaries and scholarships, targeting a proportion of 55% support for women pursuing postgraduate studies. These bursaries have increased the enrolment of STEM postgraduates from 50% enrolment in 2011/2012 to 53% in 2012 (ibid.:43).

A recommendation on this report was that the number of women in formal sector employment should be increased, with the aim to encourage women to study in the STEM fields. That would also assist women to take an interest in financial literacy, which is a requirement for them to access finances (ibid.:147).

This scenario is an indication that a lot still needs to be done to turn the situation around. Strategies such as an awareness programme developed out of the findings and recommendations of this study are necessary, in addition to other initiatives that are already there, to consolidate and strengthen the situation. One such strategy that has achieved good results in trying to improve the low numbers of girls in the STEM fields in South African high schools is the Techno-girl programme. It was established in 2005. The Techno-girl programme identifies girls from previously disadvantaged communities through the Department of Basic Education and places them in structured job shadowing programmes at various organisations during school holidays. The ultimate goal of Techno-girl is to expose girls to the world of work, in the STEM fields in order to enable them to make informed career choices beyond schooling. The other embedded aim is for the workplaces where the girls are placed to ultimately take them up as employees or/and even provide them with bursaries for their tertiary studies if possible (Techno-girl, 2015:2).

As a result of this programme, of the 1391 girls who completed the job shadowing phase of Techno-girl for the Grade 12 National Senior Certificate examinations in 2015, only 1280 (92%) were contactable. It was then found that for Grade 12 results, 824 (64%) achieved a Bachelor pass, 272 (21%) a Diploma pass and 66 (0.05%) a Higher Certificate (Techno-girl, 2015:3). For a developing country, this scenario is proof that South Africa can succeed but not much has been done so far to develop girls and young women to join the STEM fields in larger numbers. This study therefore identified this need; hence the investigation was followed by an awareness programme in that regard.

According to Shepherd (2017:2), many ‘high-paying’ and ‘high-skilled’ occupations in the developed countries are in the STEM fields. South Africa is still a developing country but the same scenario is already prevailing in her labour market. This is because science and technology have been emerging as the drivers of profound social change and economic growth. Thus, they can play a significant role in the economic empowerment of women.

Based on the above observations, I believe that science and technology, together with the rest of the STEM fields can indeed empower young women economically and

transform their lives in general. These conclusions will, however, need robust turn-around programmes. Shepherd (2017:2) reported that in 2012, women who enrolled for undergraduate degrees in the fields of engineering and computer science formed less than 30% of all students at the level of tertiary education in South Africa. This means a lot still has to be done.

Shepherd (2017) recommends one powerful programme for the achievement of motivation, named 'Self-determination theory' (SDT). It formed a foundation for contemporary research. It has proven to be effective by 'giving rise to action'. SDT distinguishes between the intrinsic and extrinsic types of motivation. Intrinsic is the most basic one, where one is motivated to do something based on the inherent interest or because it is enjoyable to perform. It is also said to be 'critical to cognitive and social development'. On the other hand, the extrinsic type is when one becomes motivated to do something because it will result in an independent outcome, such as performing well in a project. Motivational sessions, though not called the SDT or structured as above, are part of the designed awareness programme as an outcome of this study, since for young women to change the cultural perceptions and gender stereotypes attached to the STEM fields, there is a need for both intrinsic and extrinsic types of motivation. The discovery of the significance of the STEM fields and that they can be done by both men and women, forms part of motivation for young women to derive interest in choosing a career in these fields as well as performing well.

2.11 GAPS IN THE CURRENT STEM FIELDS' PROGRAMMES

A variety of good programmes have been initiated and implemented to alleviate the situation of women regarding their underrepresentation in places and areas where their male counterparts are already dominating. So far, there is no knowledge of programmes that boldly talk about increasing the participation of young women in the STEM fields in South African universities. There are, however, programmes that can serve as models in terms of their robust intention to improve participation of women in the fields and spaces where their numbers are insignificant.

Good lessons and principles were taken and used in developing the outcome of this study, an awareness to improve the participation of young women in the STEM fields in South African universities, from programmes such as staffing South Africa's

university framework (SSAUF), initiated by the DHET in 2015. According to the DHET (2015:6), South African universities are undergoing challenges in terms of, not only the size, but also the composition and capacity of academic staff. As a result, DHET and universities have formed a partnership and developed the SSAUF. The SSAUF took the baton from the Higher Education South Africa (HESA) task team, using its report titled, *Proposal for a National Programme to Develop the Next Generation of Academics for South African Higher Education*, (South Africa, HESA, 2011). This report had a number of valuable proposals that were taken up in the development of the SSAUF.

While the SSAUF's point of departure is to 'recruit, support and retain black academic staff to address their very serious under-representation at all levels in the sector and to create awareness of the importance of the academic field as a career for those with the potential', (DHET, 2015:6), I believe that the target profile should further be disaggregated in terms of gender, age and fields, going forward. Future research may have to include the recruitment of young, female, academic staff members in the STEM fields within these institutions, since women are said to constitute 44.6% of the staff in universities, despite their proportion of 51% in the population (DHET, 2015:7–8). I believe that with more female academic role models lecturing in the STEM fields, there will be an increase of young women who take up careers in those fields in South African universities, as an addition to all other relevant programmes, including the one I have developed in this research.

In addition to 'effective recruitment' of black academic staff, the SSAUF also advocates for the development and induction of the recruited staff into an academic career. The reason cited for this is to ensure 'greater retention' of academics within the system (DHET, 2015:6). One of the dilemmas mentioned by Erwin and Maurutto (1998:52) is that few as women are in the STEM fields, most of them leave these fields at some stage and join other sectors.

What the SSAUF says to the reader is that, development and induction lead towards greater retention of staff. As a result, development and induction are given a space as part of the programme in chapter six of this study, with the intention to motivate and encourage young women to not only be attracted to the STEM fields but also that

these fields should have greater retention of young women's talent, which is currently a challenge. All the above strategies should be implemented in consideration of the current scenario in the STEM fields as per researches mentioned in this study and many others because these fields are dominated by the patriarchal stereotypes of some of those who are serving in these fields at present. Such hindrances need to be dealt with while at the same time enabling professional autonomy of young women in pursuing their studies in the STEM fields as well as encouraging them to access the level of posts that will give them satisfaction at universities and elsewhere, through relevant programmes.

The accessibility to the science programmes implemented so far seem not to have succeeded in motivating or encouraging women to study and stay in the science fields at higher levels. This is despite the fact that women start these fields as committed as their male counterparts and in most cases, according to a number of researches mentioned in this study, perform slightly better than them. In their report Erwin and Maurutto (1998:52) suspected that during their studies, something happens that 'undermines' and discourages women completely, thus taking away their interest and ambitions in the science fields. This finding is made as a result of the research they had conducted with the purpose to determine what happens to deter women's commitment to the science fields, but more importantly, what is the reaction and interpretation of what is happening. To that effect, 91 undergraduate female students were interviewed. The interviewees were questioned on what determined their educational and choice of careers. The aim was also to find out if social class, race and gender have some influence in that regard (1998:53). The predominant focus in the literature has identified differences in innate ability and early socialisation practices to explain why girls tend to avoid science in primary and secondary schooling, which happens in both developing and developed countries. The studies on post-secondary attrition show that in numbers, science undergraduate female students almost equal their male counterparts. However, at higher levels female student numbers decline, as if the undergraduate level is their decision-making stage to leave the sciences.

The STEM female students who graduated from universities were found to be earning lower salaries than their male counterparts and they were not progressing as well in their careers as male students. This was stated in the US's National Centre for

Education Statistics report of 1997 (Christiea *et al*., 2017: 2). An extensive review conducted by Eisenhart and Finkel (1998) on US women in science agreed with this report that females normally occupied lower-level positions in the engineering and science fields. What is even more disappointing is the 2013 report by the National Centre for Education Statistics (2013), nearly two decades later, revealing that the US gender gap in the STEM subjects remains still the same at university level and that other developed countries like Australia shared the same result. Moreover, Australia's national estimates suggested that in the engineering field in particular, enrolment numbers have declined more than figures for retention, which is a matter of concern.

In her doctoral thesis, Reid outlines that the under-representation of women in the STEM fields could pose later threats to the nation's long-term prosperity and security. She quotes the report *The Science and Engineering Workforce: Realising America's Potential* (2003) which states some of the problems as stagnant or reduced students' interest in the STEM disciplines, projected retirement increase from the STEM workforce, projected rapid growth in science and engineering occupations, anticipated growth in US citizens with science and engineering skills for jobs related to national security and severe pressure on the State and the local budget for the science and engineering education (Reid, 2009:2). The under-representation of American women in the STEM is the disease of many nations and has to be intentionally remedied through the relevant programmes.

One of the reasons is that African American women are in the minority and their under-representation in the STEM is that they are experiencing race and gender discrimination and are not prioritised for support as are their white counterparts who are referred to as universal subjects. African American men are, however, regarded as a universal racial subject. For African American women, race and gender are 'linked and simultaneous' and when the two are combined, they are said to be producing 'race-specific gender effects' that generate important experiential cleavages among women. Unfortunately, African American women are not taken as a group to be heard on its own and for its own sake. However, they occupy a critical proportion of the STEM workforce in future; currently, they are an untapped source of talent (Reid, 2009:3).

The ‘untapped source of talent’ in South Africa is in the form of young women who need different programmes but most importantly, awareness programmes, so that they are able to define their current status in the labour market and the causes thereof, in order to design their way forward with the help of other programmes. Reid (2009:19) highlights the importance of funding programmes that assist in rooting out the past stereotypes and improving not only educational opportunities but also STEM courses and careers for women and girls, as well as programmes that eliminate any kind of discrimination. Such programmes need to be put in place for financial support to those who are capable but have no means. According to Reid (2009:30), students flock to the STEM subjects when there is continuous motivation that strengthens their interest.

This kind of motivation is also desperately needed to close the talent gap in the knowledge industries. It is known globally that the number of women in the science and technology-based careers is very low and yet these industries are the key to a strong future economy. ACTO (2014:i) reports that Ireland aspires to lead the world of the future in technology, science and engineering. However, there is one main challenge that troubles different enterprises, large and small, i.e. acquiring and producing the best talent in these critical and scarce industries.

The implication in the ACTO (2014) report is that if any country, including South Africa, wants to be counted as part of sound future economy, it should look for the best talent in the critical and scarce industries, i.e. the STEM fields. The report also implies that women should form part of this good future economy since currently too few women are occupying a small percentage of the technical careers, which leaves the economy still in a poor state. Improvement in the participation of young women in the STEM careers is therefore necessary for this country.

According to this ACTO (2014:1–3) report, the Irish Minister of State for Training and Skills stated his intention to prioritise the removal of any obstacles that may be in the way of the country’s economic recovery, by ensuring the inclusion of all available talent and improving the under-representation of women, at less than 25%, in science- and technology-based careers. The ACTO report therefore became important to the research findings by suggesting that ‘female students and their parents are struggling to make informed decisions when it comes to choosing subjects in secondary schools

because of a number of barriers'. These barriers are unfortunately contributing to the shortage of women in the STEM fields. The key barriers include the following:

- Negative stereotypes suggesting that STEM fields are more suitable for boys and that the STEM subjects are very difficult;
- Insufficient information on the part of parents who are the main influence on their daughters' choice of career paths, regarding STEM career options;
- Fragmentation of information on STEM careers, making it difficult for students and their parents to evaluate options;
- Disconnection between the skills needed by the industry and the students' subject choices for their leaving certificate examinations (final year).

The ACTO (2014:3) report also states that the unemployment rate in Ireland is standing at 13% and that the STEM skills offer great potential for reducing unemployment and improving economic growth. It also reports that companies requiring STEM skills are having difficulty filling posts that are always readily available. Therefore, fostering an interest and curiosity among female students in the STEM subjects and career opportunities at an early age will assist the government, academia and industry to get the STEM talent pipeline flowing, which in turn could strengthen technology economy. With an unemployment rate in South Africa that is probably higher than that of Ireland, this country may also want to encourage female students to take up careers in the STEM fields.

Xu (2015:116) warned against what might be a long-overlooked gap, 'the role of women's gender negotiation' within the STEM fields, which may best explain the difference between the number of women and men in that sector. Gender negotiation relates to the way in which gender may, or may not, impact on the students' experiences in these fields. It also includes the awareness or unawareness of the STEM sector on issues of gender. In the case where the sector is not aware of or does not embrace such issues, the impact may be on women's decision-making and choice not to select and persist in the STEM fields. Women's choices to pursue the STEM fields will then be reflected in the successful proceedings and outcomes of this gender negotiation. The way in which gender issues will be handled, activities unfolding and undergraduate women's experiences structured (whether activities will be expressed

in a masculine or feminine nature) will impact on whether there will be growth in the number of women in STEM fields.

In view of the above information, it is important for gender mainstreaming to be implemented in all sectors, to raise awareness of gender issues as well as to work towards gender equality, which is one of the sharpest instruments of socioeconomic transformation. Part of the outcome of this study alludes to gender responsive budgeting, where sectors are advised to integrate gender issues in their annual budgeting processes. This should embrace gender programming and sustain the recruitment, as well as the retention of women in the STEM fields.

According to Dawson, Bernstein and Bekki (2015:53), there is a lot of evidence currently accumulating, to prove that women's persistence in the sciences and engineering fields is directly linked to the availability of a strong mentor, as reported from the National Academy of Engineering and Institute of Medicine of 2007, by the National Academy of Sciences. The three authors used an example in Preston's study of 2004, where six out of seven women identified a lack of guidance and support as a reason for their decision to leave science. On the other hand, women who had received mentoring during graduate school completed their graduate programmes at a rate of 100% as compared to 60% among women who did not receive mentoring during their graduate years. These authors (2015:55), also reported that psychosocial support offered by mentors moderates the effect of environmental barriers on psychological outcomes and that this phenomenon can best be understood within the context of social support, which implies that encouragement creates a sense of security and casts out a sense of isolation. It provides a sense of protection against stress and mood swing disorders, as well as physical symptoms. Importantly,
'psychosocial support contributes to stress resilience and career satisfaction by increasing positivity, cognitive flexibility, sense of meaning, empowerment and active coping strategies' (ibid.). Therefore, psychosocial support programmes should be integrated with all initiatives that are meant to increase the participation of women in the STEM fields.

UNESCO (2016:2) reported on the relatively low proportion of female students who are enrolled in the STEM-related programmes at tertiary level and the fact that in the

labour market women make up only 15% of Japanese researchers as well as only 18% of Korean researchers in the science, technology and innovation fields. Contrary to that, more than 50% of the researchers in Kazakhstan and Thailand are females. In Programme for International Student Assessment (PISA) in 2012, girls had an equal score with boys in mathematics and outscored boys in science; in Kazakhstan and Thailand girls outscored boys in both mathematics and science. It is also reported that in both these countries, female students comprise more than half of the students enrolled in the science programmes although women still make up 32% in Kazakhstan and 24% in Thailand in the engineering, manufacturing and construction fields. Programmes such as PISA, provide a positive indication that with more effort and support, women's numbers can be increased in the science and mathematics fields.

According to UNESCO (2016**:**3), some of the reasons for the continuous underrepresentation of women in the STEM fields are a lack of gender-responsive teacher training in the STEM-related subjects. The teaching and learning materials are said to still permeate gender stereotypes, while socio-cultural and other educational factors result in gender disparity in subject preferences and perceived performance, to the extent that girls are less likely to be encouraged to study STEM subjects by parents and teachers. These gender stereotypes and norms lead to women within STEM being concentrated within certain careers. In agreement to this, Cummings (2015:4) reported that throughout the world, there had been many interventions that had been shown to promote cultural change at all levels of education and employment. These include the STEAM fields.

Moreover, there has not been any data developed to monitor career progression in the STEAM fields, much needed in the developing world. Activities planned should be guided by data and policies, in order to increase the rates of women entering the labour market, their retention, promotion and advancement to leadership positions. My view is that this would serve as evidence of progress and the means of attracting women to STEM subjects, as well as those who are considering joining these fields.

One of the most difficult processes in the developing countries is that of establishing evidence-based interventions and policies as well as reporting on them. In some cases, data would be available for reporting but it would not be properly packaged

according to international standards. As a result, such data would not be of great use in forming a foundation for quality and integrity, the two attributes that are necessary for building a national vigorous statistical baseline. In order for the nation's statistical data to benefit all and be useful in analysing the required investments and also to meet the international levels, it has to be disaggregated in terms of sex, among other factors, and also embrace a variety of indicators, in order to cover the socioeconomic and cultural environments for all regions within the country (Cummings, 2015:4). In the same manner, programmes and initiatives implemented to increase the participation of young women in the STEM fields should keep data bases that are gender disaggregated, in order to create awareness of the statistics of women who are already in the STEM, for the sector to understand the scope that still needs to be covered, in balancing the scale between men and women.

Cultural change, as explained by Cummings (2015:4), is critical in all initiatives and interventions in developing countries. The education of girls and women should be prioritized in the fields where males are still dominating. This report also encourages initiatives that create awareness and provides knowledge to the beneficiaries, involving both local and global partners. 'In-depth gender impact metrics' (ibid.) and gender responsive funding are recommended, in order to enable sustainable changes in the empowerment of women that would ensure their equal representation in society at large and in the STEM education and employment as their male counterparts. This can be achieved through the relevant programmes.

The British Council (2015:11) suggests that awareness be raised among women on the programmes and schemes that are implemented by the government. There should also be orientation programmes and workshops organised for women students and scientists, as follows:

- Partnerships should be formed with women scientists and they should be invited to attend international conferences and workshops;
- Whenever there is a need and if possible, child day and elderly care facilities should be provided during such conferences and workshops;
- Government should mandate that for every conference delegation, there has to be female representation as well;

- For the aged women scientists, the work-load should be reduced and allow for relaxation in the implementation of programmes and projects;
- In understanding diversity, the visiting women scientists should be encouraged to teach at foreign universities for experience and progress.

The above suggestions have added value to this study, especially on ensuring that there is child and elderly care where possible during conferences. This concept speaks directly to the issues that inhibit some women from participating fully in certain activities such as attending international conferences because of their roles as immediate caregivers to their children and the elderly.

2.12 STRENGTHENING OPPORTUNITIES TO CLOSE GAPS IN STEM FIELDS

In trying to strengthen the existing opportunities and in order to close the gaps identified in previous sections of this study, a number of lessons have been learnt from other countries and contextualised to suit the scenario in South Africa. Baltodano *et al.* (2012:67) reported that in Michigan (a US state), State Network partnered with the Women's Commission, funded by the Michigan Department of Labour and organised three annual workshops for women students, free of charge. Each workshop included leadership skills development and mentorship sessions.

The report states that the 2010 workshops, which were held on three different university campuses, were attended by 292 women students and 87 mentors from business, education, public service, human services, science and technology. Impact analysis was conducted and the findings indicated that there is great improvement from these workshops, e.g. the establishment of a website, publicity, conference invitations, follow-ups and most importantly, mentor identification. The need to use social media as one of the instruments for mentoring was mentioned by one student participant in this study. As part of the outcome, I have also identified stakeholders, who are leaders in their different sectors, who should be used to strengthen the STEM sector in the form of workshops, in addition to social media and other effective tools.

One such tool, which is regularly used nowadays, is breakfast programmes, through which skills for leadership, communication, mentoring and others are transferred.

What is even more important and practical, is the element of networking after the platform for a specific theme that is attached to it. According to Baltodano *et al.* (2012:68), the State Network also organised regional breakfasts in Pennsylvania from the year 2001, as a strategy to reach women at a wide range of universities. The breakfast programmes included keynote addresses by popular figures, occupying powerful leadership positions. The main topics were on leadership and 'meeting the needs of the next generation of students', embracing the 'tension between continuity and change' and 'helping women to explore their own personal journeys'. What was also important was that the programme also allocated enough time for networking among women on discussions based on the topics of the day. The creation of the platform for networking works better for students as they are given the opportunity to identify suitable mentors and can actually start the discussion on the spot.

Christiea *et al*. (2017:3) mentioned another scheme that was introduced in 2009 by Ghent University, in Belgium. Its purpose was to provide young female PhD researchers with mentors. This resulted in an increase in the visibility of female role models in engineering and other STEM subjects. It highlights the importance, excellence and exceptional impact which is brought about by women in STEM fields.

The publication of an annual calendar, that illustrates women and their achievements in various scientific fields, by Gender Equality Observatory, is an example of activities that are adding great value to this initiative. These authors allude to an incident in 2010 when the above-mentioned calendar was focusing on women in the field of chemistry. The Australian government has also been reported to have introduced a Maths and Science Partnerships' Program (AMSPP) project, managed by its Department of Education Science and Training (DEST), amounting to $16.4 million, which will be spread over three years, for the delivery of innovative mathematics and science projects in all Australian universities, to increase participation of both males and females in STEM. The main purpose is to 'improve student engagement in Maths and science courses through innovative partnerships between universities, schools, and other relevant organisations'.

Impressed by the above activities, I made a recommendation as part of the outcome of this study, for universities to conduct outreach projects on identified topics at least

once in an academic term, invite STEM women within these institutions as well as women role models in such fields for breakfast. That would be better on a live breakfast show as part of the marketing strategy.

Some strategies are in the form of projects, like the one previously mentioned in this study, with the aim of improving recruitment, retention and gender equity in higher education. The IRIS Project was recommended by Elster (2014:58), for its provision of support to first-year students, in order to prevent dropouts, by advising them of how important, interesting and meaningful STEM education is to their future lives. It was used to make them understand that these fields would contribute to the realisation of their full potential. STEM education would also strengthen their self-efficacy and reduce the impact of received cost. The project would ensure that students, and in particular female students, were supported through mentoring programmes by integrating their academic and social lives. Hazari *et al*. (2017:15, 18), on the other hand, suggested that STEM educators also need to be supported, since they are often concerned that they are not able to reach every student in class but only a few, selected ones, with whom they interact individually.

Fortunately, with the introduction of active learning environment programmes, which promote a communal approach to learning, a student should have a number of peers to rely on for motivation and the facilitation of learning. This will assist in the integration of education and holistic development.

Policymakers and academics in the field of development have started to pay attention to the relationship between education and development. The MDGs, UNESCO and World Bank's Education for All (EFA) and Fast-track Initiatives, all share the same sentiment regarding this subject as well as the importance of girls' and women's education. Ever since the turn of the millennium, higher education has been prioritised, especially in its relation to economic growth and development (Tjomsland, 2009:408). Since the STEM fields are said to be economically empowering in terms of high salaries and availability of jobs, there is a need to prioritise them and encourage young women to participate for sustainability.

In its report on the year 2000, the World Bank proclaimed a new thesis that has interest in the knowledge of science, communication and technology, in order to close the gap between south and north. Subsequently, in 2002 and 2008, the World Bank followed up on that thesis with policy reports. Previously, the policy had suggested that higher education was to the benefit of the individual and not for social development, until the above report was published. The role of women in relation to higher education and development had been given minimal attention and only a few academic studies had focused on the effect of women's higher education on social development (Tjomsland, 2009:408). However, as a result of the above reports, all that is changing. Programmes like the 'New Generation of Academics', which is situated in the Department of Higher Education and Training, have been introduced to address the integration of education with development in order to bring about transformation in the education system.

Part of that transformation involves diversity in thinking and creativity in the STEM fields. According to Ureksoy (2011:5), in 2007 the National Science Board introduced some of their 10 priorities for the 21st century in order to supply scientists, engineers and science teachers. The aim was to increase women's participation in those fields in order to improve the economy of the country (US) through diversity in thinking and creativity in the STEM fields. It would also expand the scope of careers for young women. Ureksoy's intention in this study was to apply organisational theory and methodology to the study of undergraduate engineering and to delineate the components of the academic climate which support the persistence of its undergraduate engineering students. Organisational theory would be applied to the empirical study and the relationship between the climate perceptions and undergraduate commitment and withdrawal intentions. Issues pertaining to women and STEM fields were also looked at, i.e. the relationship between people and the environment in the academic programme and how it could shape students' commitment in the programme; issues such as socioeconomic status, influence of parents and high school courses and achievements; students' interaction with the environment around them, which then reinforces or alters their original plans and goals. However, young women's participation in the engineering fields remained very low. There was a need for solutions designed to attract and retain young women in the engineering fields. The 'chilly' climate was blamed as one of the reasons for the underrepresentation of women in those fields (Ureksoy, 2011:6, 8).

The fact that the cause for lack of retention was blamed on the ‘chilly environment’ in the research above could mean there was no ‘diversity in thinking and creativity’ under which learning was taking place. The role of organisational conditions is important for understanding outcomes among the individuals. Understanding the experiences of women in the undergraduate STEM programmes, such as persistence, need to be observed. Partnerships should be forged between schools and universities, to bridge the gap between these two different institutions of learning. Jakes (2013:7) calls for the creation of smooth transitions between high school and college by aligning the academic standards of both institutions. The DHET may be utilised to mediate in that regard. That would provide all students in the education system relaxed and fearless learning environments, leading to academic achievements. This author further suggests that the STEM careers can provide women with increased and sustainable economic security, more than that rendered by other fields. An awareness programme, developed as an outcome of this study, would contribute to that.

The Advocacy and Participatory Worldview Programme, as per Jakes (2013: 9 and 16), is recommended to identify specific and current social issues like empowerment, inequality, oppression, domination, suppression and alienation. Regular research needs to be conducted while evaluation and periodic upgrades should be done and used to guide educational reforms, in an effort to improving student success. In addition to the above Jakes (2013:23) also advises that the curriculum be aligned with regular data collection and that reporting systems be in place, in order to reduce the challenges of transitions between educational levels, i.e. school and college/university education.

New data on the gender gap in the science and technology fields was released by the US Department of Commerce, checking on the impact of economy on women. The study discovered that women were occupying about 50% of all jobs in the US but less than 25% of those in STEM fields. This trend continued even though women in STEM careers earned 33% more, on average than women who work in other fields. The data also showed that women who were studying STEM fields in colleges were not necessarily going to work in such fields. While 40% of men with a STEM degree work

in the science and technology fields, only 26% of comparable women do so (Jakes, 2013:1, 18–19).

In 1993, Dr P. Ambedkar Open University (BRAOU) established Women's Studies Cell which was later renamed as the Centre for Women's Development and Extension Centre. The main objectives were to:

- Critically study the challenges, aspirations and needs of women learners who constituted 35% of the university's student enrolment;
- Provide the necessary information, knowledge and skills for economic empowerment of women, especially those who were still studying and their families;
- Enhance access to women's legal rights and information, as well as their entitlements in the society;
- Organize more activities in the areas of literacy, health, nutrition, environment and entrepreneurship, as part of developmental measures for women (Satyanarayana & Meduri, 1982:2).

Structures like the one above, which are meant to cater for the needs of women learners and their aspirations, have to be established in all universities and more importantly, within academic departments of the STEM fields, where women are in small numbers and need to be supported more. Such structures should also be extended beyond universities, to the world of work, where retention is a challenge.

The labour market had about 61.4% female graduates whilst their male counterparts registered 91.4%. Freeman, Marginson and Tytler (2015:36) quoted from the report on the status of women in science and engineering (MEST & WISET) of 2012. This report also highlighted that, even though the proportion of women working in the science and engineering fields increased in mid-2000, more than half of them still work in temporary jobs. What is even more disturbing contained in this report is that women in science and technology tend to discontinue working in these career fields after pregnancy, childbirth and child rearing, similar to general workers in Korea. A lower number of women in the science fields return to the labour market after their mid or late thirties than women in all other careers.

In remedying the above situation, the Korean government implemented policies and established the Korea Advanced Institute of Supporting Women in Science, Engineering and Technology (WISET). This policy was the master plan to support and foster science and engineering and was to be implemented in different phases, i.e. 2004–08 and 2009–13. The main policy programmes within these master plans were inclusive of 4W projects, i.e. a mentoring programme between renowned women in STEM and female students from elementary school through college and also promoted the career development of women in STEM, including those who are working and seek to return to work in such fields. It is reported that the evaluation of the 4W projects has shown great success by encouraging female students to pursue science and engineering studies and develop careers in these fields. As a result, the difference between male and female high school students in pursuing the natural sciences and engineering decreased from 20% in 1999 to 18.9% in 2009 (Freeman, Marginson & Tytler, 2015:36).

2.13 CONCLUSION

Literature from different periods of time, e.g. 1998 to 2017, has been consulted and mention made of the efforts to encourage women to take up careers in the STEM fields. There had been some improvements but the pace of growth was too slow. In some cases, the status quo remained the same or deteriorated. This literature study has revealed enough evidence that women have indeed made strides, participating in numbers in higher education institutions worldwide though sustainability has been a challenge. In South Africa particularly, women's numbers have proved to be higher than those of their male counterparts in universities. However, it is only a small proportion of young women who are taking up careers in the STEM fields. Unfortunately, these skills are said to be scarce, critical and badly needed in the workplace because of their ability to improve the economy of the country.

Enough evidence has also been provided that there is no difference in the intellectual capacity of men and women that may be used to explain the underrepresentation of women in the STEM fields and their overrepresentation in the social and humanities fields. This study has made a contribution through its findings of some of the causes of the above situation, which leaves women at the bottom of the development pyramid,

in terms of low salaries, low-skills level and employment with fewer opportunities than for their male counterparts.

Lack of gender mainstreaming seems to be one of the biggest gaps in the STEM sector since some research has discovered that women found the fields to be a ‘chilled’ environment. As a result, women have to constantly negotiate for gender recognition. In this study, the distinctive issues of women were highlighted, advocated for and integrated into the young women’s intentional awareness programme that developed as its outcome. Periodic evaluations will be performed as part of this programme, to ensure smooth implementation, relevance, sustainability and impact analysis.

CHAPTER THREE

THEORETICAL FRAMEWORK

3.1 INTRODUCTION

Chapter three outlines theories that guided this research. These are philosophies and beliefs that have had a great influence in the career choices of young women in South African universities in general. Each of these theories contributed to young women's choice of a career in one way or another, which gave rise to the situation of their limited participation in the STEM fields. However, understanding how these theories influenced such choices, led to my development of a suitable awareness programme, aimed at improving the participation of young women in the STEM fields while at the same time acknowledging the influence these theories have in the lives of young women.

3.2 RESEARCH THEORIES

3.2.1 Feminist theory

Part of the philosophical underpinning of this study is the feminist theory, which assisted in investigating the source of influence on the choice of careers of young women, whether young women's choice of careers is feministic by nature or not. The reason for selecting it as one of the related theories in this study is because this research seeks to investigate issues relating to young women, i.e. the source of influence on the choices of careers of young women at South African universities. Terre Blanche, Durrheim and Painter (2006:502–503) explained that this theory covers a number of related issues leading towards our understanding of the behaviour of women, as a result of their experiences, that has an impact on the choices they make in their lives, which is in the case of this study, their preference of careers in the social sciences in big numbers, as compared to the STEM fields.

According to Ledwith and Manfredi (2000:20), the influence that is brought about by the experiences of women is evident in the study they did, where a younger woman who was participating in the research wanted to 'balance the act' by spacing out her maternity leave among the three children she planned to have in future in such a way that these leave periods would be granted by three different employers as she climbed

her career ladder. In the same study, senior women appreciated the latest support given to them in the form of paid childcare, which seems to be a concern where this opportunity does not exist. This indicates that women take into consideration their experiences, such as childbearing, child care, and the impact these have on their future lives, when they choose and plan their careers. The above scenarios have the issue of socialization in them, where women take it upon themselves and plan the birth of the child, ensuring that child care is paid for, as if that is their sole responsibility, whereas the fathers of their children should also plan together with them and worry about the same issues themselves.

In agreement though slightly different, Erwin and Maurutto (1998:54) discovered that in their study, socio-psychological factors have a great influence on women's choice of science careers. Those factors were found to be based on women's traditional gender roles, socialization and perceptions that they were not made for science. This study had an obligation therefore to investigate if socio-psychological factors were not the cause of low self-efficacy in the STEM fields for young women in South African universities. If that was the case, in line with the above findings, it would be beneficial for socialisation on the STEM fields to take place right from the early childhood development stages of children, for smooth progression into higher education institutions. Teachers should also be trained to be good role-models on mentoring these subjects throughout schooling, in order to enable all interested children to be accustomed to these subjects. That would give girls good experiences in the STEM fields right from an early age and assist them to achieve expected results as young women in institutions of higher learning. Up-skilling programmes to upgrade young women's mathematical knowledge from their primary and secondary schooling are also necessary, so that they can confidently embrace their STEM education at higher levels, including in the workplaces.

Savela and O'Brien (2016:336) also conducted a study to explore whether expectations about work-family conflict and the willingness to compromise a career for future children play a role in young women's early career development, i.e. career choice, traditionalism, leadership aspirations and occupational engagement. These authors' study is supporting the findings of the above studies in that, the role of women as child-bearers and child careers do have an impact on their choice of a career.

However, Savela and O'Brien's study takes the research further to suggest that even the leadership aspirations of women are affected by these roles. The feminist theory seems to be at the centre of the choice of careers by women, who somehow need to ascertain that whatever careers they choose, should not clash with their roles of child-bearing and child-caring, since men are not able, biologically, to be pregnant and bear children. The decision of choosing a certain career over another because of the 'role of women, tends to be more emotional than rational'. This statement is also supported by one of the findings of the above study that, "their role as women is to give birth to children and ensure that those children are taken care of while fathers are completely exempted from these functions".

According to Terre Blanche *et al*. (2006:503), some of the reasons are that feminist research does not work well with positivist assumptions since it believes that the difference between the researcher and the research subjects maintains power relations in which the subjects become the object of research and the researcher gathers knowledge without bestowing him/herself. Feminists try to maintain balance between the researcher and the subject whereas positivist methods are perceived to be patriarchal since they try to understand the world in order to control and manipulate resources. Feminist theory pays attention to the content and the process of the research (Terre Blanche *et al*., 2006:503). As a female researcher, I was careful, not to use my experiences to justify the behaviour of the subjects in this research, i.e. young women in South African universities. Focus was ensured, to investigate what influences the choice of careers of young women in South African universities without taking tune from the above or any other related study.

3.2.2 Sexist theory

Shin and Lee (2017:4) define the sexist theory as 'prejudice or discriminatory attitudes or behaviours that promote stereotypes of socially constructed roles based on sex'. This is also supported by Gutsell and Remedios (2016:28) that sexism originates from the belief in traditional gender roles that separate the responsibilities of men and women in the family. However, these authors state that men who do not believe in the sexist theory do not expect their female partners to take most of the responsibility on care-giving but also feel accountable to ensure that future family responsibilities are

shared. Such men also want to take part in planning how their children will be raised. Therefore, ‘balancing the act’ as mentioned above should not be a women’s plan alone but of her partner as well. This implies that women should carefully consider their career choices without being influenced by their family planning as if this is an obstacle to their bright future.

One of the greatest barriers for women to be leaders, as highlighted in the report produced by the World Economic Forum, in 2012, i.e. the Corporate Gender Gap, was a lack of role models. The Silicon Republic then established the Women Invent Tomorrow, in trying to resolve that. It is an annual year initiative that highlights the importance of closing the gender gap in the science and technology-based industries and prides itself by inspiring women to be role models in the STEM fields. This initiative encourages schoolgirls to take career opportunities in the STEM sector which are said to be broad although many people are not aware of them. In other cases, girls are clouded by outdated or incorrect perceptions to avoid careers in this area (ACTO, 2014:i). This research managed to identify STEM role models, mostly within but also outside the country that would serve as motivation for young women to choose such fields as future careers.

A case presenting such outdated perceptions, as reported by Gutsell and Remedios (2016:28), was about a woman who was requesting a recommendation letter from one of them. When asked about her career plans, she responded as follows, ‘My father was a doctor and I wanted to be one too. But I also want children, so I'll probably choose a less demanding field’. What she was actually implying was that her father managed to be a doctor because even if he had children, he was a man. As a result, she could not choose the same demanding career if she wanted to bear children since she was a woman. This report illustrates how the intention to have children in the future impacts on young women's decisions to pursue ‘family-friendly’ careers in the present. It also suggests that working in the STEM fields is a lot of work that is not suitable for women who intend to have children in future.

Perceptions such as the one above result in a tendency by women to choose the ‘lower-level’, ‘soft disciplines’ and short-term tertiary education in big numbers, although their numbers are generally higher than those of men who are registered at

universities globally. This was shown in the UNDP's Human Development Index report, which tallies with the one written by Gutsell and Remedios (2016:28) that female-dominated occupations tend to be lower paying, less time-consuming and more flexible than male-dominated occupations. This could be a deliberate choice made by women because they expect to be the primary caretakers of children in future, and as a result obstruct the development of their careers.

On the effect of the sexist theory on career development, a research finding by Shin and Lee (2017:3) indicated that female college students were reported to have stronger self-efficacy when performing traditionally women-dominant occupations. Self-efficacy beliefs were also significantly related to sex differences in the fields of STEM that women were reported to have lower levels of self-efficacy in such fields as compared to men. Self-efficacy is explained as a person's belief in his/her ability to be successful in performing a behaviour that influences the decision, whether to engage in that behaviour and how much effort should be exerted. Career decision self-efficacy is defined as 'individual's confidence of engaging in tasks associated with making career choice and committing a career successfully' (Shin & Lee, 2017:2). In agreement, Jakes (2013:6–7) reports that gender equity in the workplace can result in the improvement of self-esteem of individuals. Equitable salaries and increased opportunities for men and women who are doing the same type of work will indeed encourage women to join the STEM fields in numbers.

As a result of the above, gender equity has been embraced in the outcome of this study, where sectors are encouraged to distribute resources, especially bursaries in the STEM fields, equitably, according to the demographics of men and women in those fields. The gender-responsive budgeting that had been integrated in the awareness programme developed in chapter six, will enable the STEM fields to move faster towards gender equality if planning and implementation take place as recommended. This includes no discrimination in the treatment of young women and young men.

3.2.3 Classist theory

Shin and Lee (2017:3) define the classist theory as 'prejudice and discrimination based on social class resulting from different social classes'. These authors regard the

classist theory as the most fundamental and influential variable that acts as a barrier in a person's career decision-making process and its results. The Department of Women (2015:10) reported that at the end of Apartheid, women, especially those from rural areas, seemed to be poorer than their male counterparts and that African and coloured women were worse off, compared to Asian and white women. What also stood out as a result of this situation was that the participation of women in higher education improved but the pass rate in mathematics, science and technology in Grade 12 remained higher for male than for female learners. This case presents evidence of the result of the classist theory where female students seem to be disadvantaged by underperforming in the STEM fields in schools, which lays a foundation for their career choices at a university. Furthermore, the Department of Women (2015:10) also reported that beyond the Apartheid era, the government provided a full range of support and resources that were made available and meant to facilitate career development processes. This research discovered that indeed, the classist theory had an impact on the current status of lower numbers of women in general, and young women in particular, in South African universities.

Closely related to the above is the study that was done by Latchanah and Singh ([sa]: 37). Their report states that there is a gap in the representation of women at more senior management levels, referred to as the 'glass ceiling'. The study on the glass ceiling focused on the barriers to the progression of women, as a result of their social roles, personal characteristics and situational barriers. Situational factors appeared to be clear barriers to the progression of women. They ranged from gender discrimination to lack of respect by male colleagues to diminishing the multiple roles that women play in their families, commitments and relocation. The recommendations of the study were that, unless all barriers are dealt with, women may never progress to higher-level positions in their workplaces (Latchanah & Singh, [sa]:45). The outcome of this study laid the foundation for this investigation to recommend rooting out whatever obstacle seems to be preventing the invasion of young women in the STEM fields in universities, as a result of classification stereotypes.

According to Fouad *et al*. (2014: 355–356), the state of the economy has deteriorated over the past few years causing a shortage in the availability of jobs in the workforce. These authors conducted a study that examined the impact of the 'economic downturn' on the emotional and intellectual factors that influence individuals on decisions they

make regarding their work. They discovered that contextual literature does not explain how people's perception of an economic downturn influences their decision-making on careers. I share the same concern in that career decision-making and choices should be guided by the state of the economy and the nation's quest for socioeconomic development and transformation. Disregard of those factors when choosing a career may lead to an element of social classes, which serve as a key marker that individuals are differently privileged and marginalized, as explained by Shin and Lee (2017:3). The incumbents may end up living below the inflation line due to inappropriate career decisions made earlier in their lives.

Jakes (2013:55) agrees with the above observations that a supportive family and its level of economy have also been found to add value to the choices made for a future career. The United Nations report (2015:1) encourages young people to acquire education and skills which are necessary to contribute towards a productive national economy. The ACTO report (2014:i) also warns of global warming, which requires a shift towards more technological careers.

Since young women are said to be a scarce labour force in the STEM fields (Erwin & Maurutto, 1998:52), there is a need to continuously encourage and enable them to close this gap as a turnaround strategy to curb further economic downturn in this and future generations. For that study, young women were 'the missing class' within the STEM fields and an awareness programme was developed that suggested strategies that would correct the situation. This is the case in this country as well, where young women join a university by considering its location and most importantly the cost of the STEM fields in comparison with all other fields that were initially preferred. In most cases, lectures in different fields are offered in the same location/area at universities but the costs are in most cases not equal.

3.2.4 Traditionalist and cultural theories

According to Shin and Lee (2017:3), the sexist theory is not limited to and within an individual's attitude but is also used to build socio-cultural policies and environments. Latchanah and Singh ([sa]:41) report that in most cases research participants hide their cultural identity and adopt the organisational one, in order to comply with the research conducted. This is also caused by the continuing intersection of gender and

race that normally brings about conflict between balancing work and family responsibilities. In the reported case, the research participants noted that balancing professional culture and their personal culture, which was African, could not be achieved because the two cultures have different demands that are normally conflicting. According to the report, women are still regarded as the bearers of primary family responsibilities like domestic chores but management does not accommodate or prioritise such duties over work.

The above research bore the same results as a different study where it was found that the role and status of women within societies are derived from traditional beliefs and cultural attitudes. The research findings presented women as complying with cultural traditions in order to be accepted and not be ostracised. However, these traditions consider women's roles to be less in value as compared to the roles of their male counterparts. Women were also expected to perform duties as wives and mothers, even if they were working and had professional responsibilities (Latchanah & Singh, [sa]:41).

Tjomsland (2009:413) supports these authors when reporting that in the more patriarchal societies, men are regarded as natural managers of subjects such as technology, science and business. This creates the impression that whatever profession or work women do, it is not expected for them to be on the same level as that of men but if women choose careers that are on the same level with those of men, it means that they are overburdened since they are still expected to perform their duties according to culture and tradition. This study therefore had also to investigate whether women avoid the STEM fields based on the fact that such fields are said to be 'demanding' while at the same time they still have binding responsibilities in line with culture and tradition after performing their professional responsibilities.

As a result of these factors, when women enter any career path that is male dominated, they are expected to prove their capability. Latchanah and Singh ([sa]:46) state that in the past women were regarded as being less competent and competitive than men, hence the justification when they started doing the same jobs as men. This somehow originated from cultural activities, from when children are brought up within certain societies. The stereotypes about what girls can and cannot do create boundaries for them in their future careers, inhibiting their success. For instance, in

the Arab countries, young women do not register in higher education to study for their future careers or to enable themselves to compete in the country's economic market. Instead, access to higher education is perceived as a ladder to gain status and prestige for young women, assisting them to compete in the 'marriage market'. In a case similar to this, Tjomsland (2009: 413–14) reports that in sub-Saharan African countries, according to cultural norms the award of a higher degree is a disadvantage to a woman who wishes to be regarded as a proper wife. Different cultures seem to have an impact on the reasons for young women who are entering higher education with the aim of choosing future careers or even participating in education at that level, let alone taking up STEM fields as careers.

Latchanah and Singh ([sa]:52-53) report that the low numbers of female students taking up technical fields as a career have resulted in a shortage of ICT specialists, impacting on the economy as well as a technology vacuum for women, which also serves as an added disadvantage to them.

ICT organisations are encouraged to create an enabling environment for female employees to 'balance their multiple roles' by introducing flexible working hours as well as a flexible workplace culture. When women return from maternity leave, they should be re-orientated through re-skilling programmes, training and development. This will allow them some flexi-time to attend to their family commitments. Even better for those organisations that have enough funding and physical space, child care facilities should be provided at the workplace. Furthermore, gender-balanced promotion committees should be established, with engendered promotion criteria that have no bias but ensure that women have equal chances for promotion with their male counterparts. Women-specific development programmes should be introduced to provide a safe and supportive environment for women to improve their self-confidence and learn new skills through mentorship and coaching (Latchanah & Singh, [sa]:52-53). Taking lessons from the above recommendations, universities could support young women to improve their participation in the STEM fields by adopting and implementing the recommendations of this study in a way that will work best for each one, without diluting its essence. This, according to Elster (2014:57-58), will also somehow address the concern of IRIS Project, which focuses on the challenge that only a few young

women choose education and careers in science and technology and therefore aims on improving recruitment, retention and gender equity patterns in higher education.

3.3 CONCLUSION

The deliberations on the above theories are an indication that women, and in particular young women, have a number of hindrances that prevent them from freely choosing careers based on their interests. Instead, their choice of careers is determined by the situation they find themselves in, which in most cases is not in their favour. Some young women may be affected by one of the four theories, e.g. feminist theory while others may be affected by all, which is far more difficult to deal with. This chapter laid a foundation, confirming the influence of all these theories that were put hypothetically at the beginning of the study, and also revealed as a reality in other countries according to the literature review. Its reality for South Africa was confirmed during data collection for this study.

As a result, the outcome of this study, an awareness programme that aims at improving the number of young women who are participating in the STEM fields, has a number of strategies that have been recommended, to remove feminist, sexist, classist, traditionalist and culturist theories as blockages that prevent young women from participating in large numbers in the STEM fields.

CHAPTER FOUR

RESEARCH DESIGN AND METHODOLOGY

4.1 INTRODUCTION

This chapter discusses the research design and methodology that have been selected for this study. The headings thereof are research approach, research assumptions, research paradigms, population and sampling, instrumentation and data collection techniques, data analysis and interpretation methods, validity and reliability/credibility and trustworthiness, research ethics and lastly, summary. Some of those headings are further broken into sub-headings that are clarified in detail for the reader's understanding.

The importance of this chapter is to introduce the method and design that was chosen for the study. It also explains and outlines the nature of the above-mentioned headings and/or subjects, as well as justifying the reasons for choosing them and not others that are used by different researchers to conduct their studies. It provides their definitions, descriptions and impact on this study and how such led to the outcome of this research, i.e. the developed awareness programme, aimed at improving the involvement of young women in the STEM fields in South African universities.

4.2 RESEARCH APPROACH

There are a number of approaches used by different researchers to realise their study goals, e.g. qualitative, quantitative and mixed method. As explained by Creswell (2019:32), these approaches are not as isolated as it may sound. Qualitative and quantitative approaches should not be regarded as firm, diverse and contrasts. Instead, they characterise different ends of the same scale. More often the difference is brought by the use of words, i.e. qualitative research is associated with words and quantitative research is more related to numbers. Mixed method researches are a combination of the elements of both the qualitative and quantitative approaches.

4.2.1 Quantitative approach

Creswell (2014:32), states that in this method, data collecting instrument is basically a questionnaire, with closed-ended questions. Quantitative research assists researchers to test objective theories by examining the relationship among variables and measures, in order for numbered data to be analysed through statistical procedures. The final written report has a set structure consisting of introduction, literature and theory, methods, results, and discussion. Those researchers who engage in this form of inquiry have assumptions about testing theories deductively, building in protections against bias, controlling for alternative explanations, and being able to generalize and replicate the findings. Creswell (2014: 32) also highlights an important aspect that another difference is brought about through basic philosophical norms brought by researchers into their studies, i.e. research strategies (e.g. experiments).

4.2.2 Qualitative approach

Qualitative researchers explore and try to understand the meaning individuals or groups ascribe to a social problem. Instead of experiments, they use case studies as one of their research strategies. In this approach, data collecting instrument is open-ended questions, in the form of interviews. The research process also includes questions and procedures that may emerge during the course of interviews. These interviews take place in the participants' choice of settings. Beyond the collection of data, analysis of such is done inductively, focusing on individual meaning, whereby themes get built from particular to the general state. Subsequently, the researcher makes interpretations of the meaning of the analysed data and finally writes a report that may take any structure, since flexibility is allowed (Creswell, 2014:32).

4.2.3 Mixed method approach

Creswell and Clark (2007:5) define the mixed method as an enquiry that guides the direction of the collection and analysis of data as well as a mixture of qualitative and quantitative data in a single study or series of studies. In addition, Creswell (2014: 32) highlights that in mixed method research, data is collected in both quantitative and qualitative forms. In that manner, the qualitative and quantitative approaches complement each other and bring about a more complete understanding of a research problem than if an enquiry was done through either one of them (Creswell, 2014: 32).

The mixed method approach was selected for this study. This implies that, this study benefitted from both quantitative and qualitative methods by using questionnaires as well as semi-structured interviews to collect data. Questionnaires helped me to gather data from a large number of participants (refer to Table 1) in a short space of time and that made this a low-cost technique, as explained by Botha *et al*. (2013:264). These authors (2013:265) also outline the advantages of questionnaires, stating that respondents get the opportunity to give their opinions without fear of recrimination or embarrassment and that data collected this way can be easily summarised and reported on. They, however, warn that questions should not be ambiguous or embedded where more questions are asked in one statement. It is also stated that questionnaires do not allow free expression of other optional answers besides the ones provided and they cannot always identify causes of problems. That assisted the study to acquire relevant and useful answers from the respondents. Towards the end of questionnaires, I had provided spaces in the last section, to allow respondents to elaborate under a specific theme and also to mention any other matter in addition to their responses. This allowed them to dispatch other related information which was not necessarily requested in any question.

Interviews are said to be a valid method of gathering data because the participants can provide their own views in the manner they prefer and are comfortable with. They can also gain insight into their own situation, which they might not have been aware of before. Interviews also gave me the opportunity to pick up emotions when respondents were answering certain questions (Botha *et al*., 2013). A student interviewee explained how she had wanted to become a medical doctor but because of lack of funding, she finally chose to be a STEM teacher. She showed emotion and related what had led to her financial unpreparedness to study medicine. During the interview, when I asked more questions for clarity, she discovered something about herself which she claimed she had not been aware of before then, that being the STEM teacher is

> ... more spiritual than anything to me. A lot of learners find it difficult to relate with people at higher levels… (She smiled as she continued.) I love the whole idea, putting myself to the learners in order to help them to take the sciences.

For in-depth questions, some participants asked for clarity and I also managed to probe questions that were not properly or fully answered. Although all questions were answered, for some respondents interviews can be stressful, even though they are a technique with a higher response rate (Botha *et al*., 2013:265). They are also perceived as time-intensive, expensive to undertake and the results may be more difficult to analyse and quantify than results from questionnaires.

Taylor (2005:250) states that quantitative research emphasizes the use of 'numerical data', hence quantitative designs focus on numbers. This author further explains that qualitative research emphasises the analysis of complex data in terms of content. In this study, the number of participants was large in all (see Table 1) and served as a good representation of the subject investigated. The roles they played and their occupations were completely different, i.e. university students, administrators and lecturers, as well as government officials. That contributed positively towards the validity and reliability of this research. The fact that participating universities are in two different provinces (refer to Map 1) and that their historical backgrounds are completely diverse, also justified the generalisation of this study's findings.

What I'd also noticed, was the same trends and opinions from participants, even though they were not from the same university and/or same nationality. The question on whether there is a difference in the performance of young women and young men in the STEM fields was responded to by two lecturers (male and female) from two participating universities, who provided me with answers that complemented each other and added value to this research. A female lecturer's response was that the performance is exactly the same. The male lecturer from the second university stated: 'Having worked in four universities so far, (I can safely say) women do better…'. The above information presents some of the main reasons and necessity for choosing a combination of both quantitative and qualitative methods, i.e. the mixed method approach, for this study.

4.3 RESEARCH ASSUMPTIONS

Creswell (2014:35) states that researchers bring beliefs into their research, i.e. post-positivism (positivism), constructivism, transformative and pragmatism. In doing so,

they position themselves in order to obtain the desired knowledge and understanding they would like to share. In each of these beliefs a specific methodology is required in order to arrive at that understanding. However, that depends on the nature of the investigation. Although pragmatism is mostly associated with mixed methods research, as argued by Creswell and Plano (2011:41), it focuses on the outcome of the research, the research question and the methods used for data collection to inform the research. It therefore addresses what works. The transformative/participatory assumption, on the other hand, is influenced by political concerns and is used where there is a need to improve society through empowerment and other issues that are related to injustice (Creswell & Plano, 2011:41). The characteristics of the positivist and constructivist assumptions are hereunder outlined since they function opposite each other and the latter have played a major role in this study. They present a clear picture of where this study originated and where it is leading, hence the focus.

4.3.1 Positivism and post-positivism

Positivism may suit researchers whose aim is to prove the objectivity of facts (Terre Blanche *et al*., 2006:9). To emphasize this, Creswell (2014:36) states that positivism is sometimes referred to as a scientific method of research. This scholar also explains the reason for calling positivism post-positivism, i.e. that it holds a deterministic philosophy, which probably determines outcomes. As a result, the problems studied by post-positivists reflect the need to identify and assess the causes that influence outcomes. Knowledge acquired through post-positivism is derived from careful observation and the extent to which reality in the world is objective. Thus, what is important for post-positivists is the development of numeric measures of observations by studying and understanding the behaviour of individuals (Creswell, 2014:36).

In this study, the indisputable fact is that there is gender disparity in the STEM fields (O'Dea & Corcoran, 2014:i) as a result of the significantly low number of young women in these fields at South African universities. What may be determined as an outcome is that there is a need for the development of a young women-specific awareness programme, in order for these numbers to improve, as it happened in countries (e.g. North Korea) that implemented policy-specific programmes to curb this situation.

A variety of causes for this situation have been identified. For example, the stereotypes in other communities that the STEM fields are for men and not for women, as well as a combination of different theories, such as the feminist and sexist theories that are outlined in chapters two and three. With the developed young women-specific, awareness programme, the identification of mentors and synergy between stakeholders, these low numbers are expected to improve.

Positivists test and verify laws and theories that govern the world, as well as refining them so that the world can be understood. Therefore, this is the scientific method where a researcher begins with a theory, collects data that either supports or refutes the theory and then makes the necessary amendments and conducts more tests (Creswell, 2014:36). In this instance, young women choose careers based on the patriarchal idea that certain careers are not meant for them, thereby avoiding anticipated complications that may be encountered in future should they decide to take up the role of child bearer, give birth, breastfeed and become mothers and wives. That theory was tested during data collection as research unfolded. According to Creswell and Plano (2011:40), post-positivism is normally associated with the quantitative approach where researchers make claims for the knowledge based on cause and effect thinking, narrowing and focusing on selected variables to interrelate items, detailed observations and measures of variables as well as testing theories that can be refined even further.

4.3.2 Constructivism/Interpretivism

Constructivism or social constructivism is often combined with interpretivism. Social constructivists maintain that individuals seek understanding of the world in which they live and work. Experiences are used to develop subjective meanings and such meanings are attached to certain things. A combination of these meanings leads the researcher to look for the complexity of views on which he/she relies to understand the participants' world (Creswell, 2014:37). Terre Blanche *et al*. (2006:9) support this author by explaining that this kind of a research may suit researchers who care about the meaning that people attach to the facts. Researchers describe realities constructed by people through a critical analysis of texts and indicate how such constructions lead to the development of certain practices, for example racial segregation in post-apartheid South Africa (Terre Blanch*e et al*., 2006:8–9).

This worldview played an important role in the current study. I adopted it so that it could help me understand how different theories such as culturist and feminist, led to the choice of careers by young women. Different researches and findings on the reasons for young women to choose other careers away from the STEM helped me to understand young women's experiences and the way they want to shape them for the future. They seemed to believe that childbearing and mothering were not only their biological roles but also their task to plan for, irrespective of the children's fathers. This seemed to be more important than choosing a career that is said to be demanding.

As explained by Latchanah and Singh ([sa]:41), one of the findings in their study around culturalism revealed that women were expected to perform duties as wives and mothers, even if they were working and have professional responsibilities and that women chose to comply with such cultural traditions in order to be accepted and not be ostracised. I could also understand how young women in general perceived their world, which was also evident during interviews with female students. This helped me to develop an awareness programme that recommends a relaxed schedule for women in the STEM fields, in order that it does not clash with the professional culture. If organisations work on flexible hours and office space, it would assist women who are pregnant and mothering to either work from home if possible or report for work at a convenient time that does not disrupt home activities.

Creswell (2014:37) explains that often these subjective meanings are based on a certain lifestyle that forms part of the people's historical background. He states that researchers also discover that their own backgrounds influence their interpretation. Therefore, their approach acknowledges the impact of their personal, cultural and historical experiences on their interpretation. The aim of the researcher is to make sense or interpret the meanings that others attach to the world. Unlike post-positivism that starts with a theory, interpretivists generate or inductively develop a theory or pattern of meaning. The historical background of South African women, under the apartheid regime, had great impact on the choice of a career. The prejudice and discrimination (separate work for men and women) that dominated this type of government resulted in what is reported by the Department of Women (2015: 10) that at the end of apartheid, women, especially those from the rural areas, seemed to be

poorer than their male counterparts and that African and coloured women were worse off, compared to Asian and white women. The highlight of this report for the current research is that although women started to participate more in higher education, the pass rate in mathematics, science and technology in Grade 12 remained higher for male than for female learners. With a historical background such as that, just over twenty years into the new dispensation it is unlikely that women would have recovered without the intended support to improve performance in the STEM subjects, hence the focus of this study.

4.4 RESEARCH PARADIGMS

Creswell (2014:35) refers to paradigms as 'worldview', meaning 'a basic set of beliefs that guide action'. He sees this as a general philosophical orientation about the world and the approach chosen by a researcher for his/her research. Worldviews originate from discipline orientations, student advisors' preferences and past research experiences. In this study, the beliefs and orientations that I picked up from the literature review, led to my decision to embrace mixed method as the approach to better understand and present the outcome of the study. For example, Ledwith and Manfredi (2000:20) show how the child-bearing experience influenced a young woman who spaced her anticipated maternity leave through different workplaces as she would be climbing her career development ladder.

Creswell and Plano (2011:41) argue that positivism/post-positivism, constructivism/interpretivism and participatory assumptions discussed above, have common elements but only differ in the nature of reality (ontology), how we gain knowledge of what we know (epistemology), the role value played in the research (axiology), the process of research (methodology) and the language of the research (rhetoric). These stances assist researchers to conduct and report their investigations accordingly. For this research, only three of the five (ontology, epistemology and methodology) are key and were applied.

Research paradigms played an important role since they outlined the nature of the investigation that I needed to undertake in order to answer the research questions stated in chapter one. These are all systems of interrelated thinking and practice that define the route that the researcher needs to take in order to achieve the objectives of

the study. This is based on the aim of the study, i.e. what the study seeks to achieve. The three paradigm dimensions are: ontology, epistemology and methodology (Terre Blanche *et al*., 2006:6).

4.4.1 Ontology

Tashakkori and Teddlie (2003:140) present the post-positivist paradigm's ontological view as the fact that there is only one reality, i.e. one truth that can be known from a certain level of probability. Terre Blanche *et al.* (2006:7) further explain that ontology stipulates the nature of reality, that which is to be investigated and what needs to be known about it. Should the researcher believe that the reality to be studied consists of people's subjective experiences of their world, she/he may then adopt the inter-subjective or interactional epistemological stance towards that reality. The use of interviews and participant observation that rely on a subjective relationship between researcher and subject may be applied. This is a characteristic of the interpretive approach, which aims at explaining the subjective reasons and meanings, leading certain social actions to occur (Terre Blanche *et al*., 2006:7). In this study, I have opted to use the characteristic outlined above, by conducting interviews and interpreting what the participants said about their world, i.e. in this case in general, how a number of theories that characterise their world influenced the choice of careers of young women, resulting in their low number in the STEM fields.

The truth in this investigation is that the numbers of young women in the STEM fields is significantly lower than those of their male counterparts in South African universities. What then needed to be known were the reasons for that, by finding out from young women in the STEM fields themselves, their male counterparts, their lecturers and government officials, who work closely with universities and provide support, to check where there could be blockages in the whole system. As a result, interviews were conducted with the subjects.

When analysing data, my experiences also helped to interpret certain statements, e.g. I could easily understand the act of parents from a traditional/cultural point of view, who believed that they had a duty to choose the right career for their daughter from the response of a young woman who complained that she did not choose a career in the STEM but she was 'bullied by her parents' to do so.

4.4.2 Epistemology

Epistemology refers to the relationship between the researcher and what is to be known. This paradigm applies in the case where the researcher believes that the subject consists of a stable and unchanging external reality, e.g. the law of gravity. He/she may then assume an objective and isolated epistemological stance towards that reality. The researcher can, as a result, use a methodology that relies on control and manipulation of reality. The purpose of this kind of investigation would be to provide an accurate description of the laws and mechanisms that operate in social life. This may be recognised as a positivist approach (Terre Blanche *et al*., 2006: 7). As Tashakkori and Teddlie (2003:141) explain, objectivity is paramount and may be achieved from observing the subject from a distant and detached position and that it is believed to be bringing a balanced and complete view of the processes and effects without any bias, as a result of misunderstanding the main viewpoints.

The unchanging reality in this study is that the world is experiencing socioeconomic challenges because of climate change and concerns about food security. To alleviate this situation, people are being encouraged to join the STEM fields (ACTO, 2014:i). However, young women are a missing talent in these fields. The fact of the matter is that young women have the ability to study the STEM subjects as well as their male counterparts, who currently dominate the sector. The literature review indicates that countries like North Korea (Marginson & Tytler, 2015:36) have put mechanisms in place to support women in the STEM fields, specifically policy programmes as control measures and to manipulate this reality. The results were positive as more women joined and stayed in the STEM. Evidence from this scenario played an important role in the development of the programme, as an outcome of this study.

As lessons from this and other research that brought about positive results, I developed a young women-specific programme with the intention to improve the participation of young women in the STEM fields in South African universities and cast away the stereotypes and societal beliefs that disadvantage women in general form benefitting by entering this sector. Since part of my study's purpose was to verify what can be used, which is already in existence, I took advantage of the fact that young women have the ability to study the STEM subjects and that fact could be used to turn

around the situation of the low numbers of young women who take up careers in the STEM fields. The aim is to change the situation, i.e. the reality under which the subject lives can be changed.

4.4.3 Methodology

According to Terre Blanche *et al*. (2006:7), if the researcher believes that reality consists of an unstable and a flexible set of social constructions, she/he may adopt a suspicious and politicized epistemological stance and apply methodologies that allow the researcher to criticise such reality. This is a characteristic of constructionist research, which aims at displaying how certain parts of the social world are produced differently and to demonstrate how such constructions of reality make certain actions possible and others impossible. Methodologies therefore specify how the researchers may go about studying what they believe can be known.

For this study, the fact that the number of young women in the STEM fields is significantly lower than that of young men, while the number of young women is already higher than that of young men in South African universities (Department of Women, 2015:34), made me suspicious and awoke in me the desire to know the reasons. My argument was that young women should be spread proportionally across different careers in these institutions, instead of flocking to certain career fields that are already oversupplied. In addition, the survey which was conducted quantitatively in this study, showed that the participants were aware of the skills that were critical to the labour market in order for them to stay employed, and in high salaried careers (see Figure 4). My other question was, 'Why would young women deliberately choose careers where there are no guarantees for them to find employment in the first place, and in addition employment that would put them at the top of the market with regard to socioeconomic sustainability?'

That suspicion was confirmed during data collection and analysis that, there are social constructions formed in the minds and hearts of boys and girls through socialisation, e.g. that girls are more exposed to cooking and boys to cars and driving. That somehow results in girls taking up careers in the social sciences and boys in the STEM fields.

The type of enquiry of this study warranted the use of mixed methods, enabling me to conduct this investigation both qualitatively and quantitatively. Implementation of these methods, however, was guided by the research question, whereby different techniques were applied in situations where they were most suitable and served in harmony with the intention of the study. For example, the background against which this study is founded presented a quantitative status quo, i.e. the number of young women is dramatically low in the STEM fields in South African universities. The technique to unpack that situation was not mainly intended to confirm if it was true or not, which would be quantitative in nature. Even though the literature reviewed confirmed the status quo, the intention was to determine the cause of that reality and if possible, turn it around. As a result, I used qualitative methodology to understand the reason and meaning presented by the subject, i.e. participants, and I also used that to interpret and pick up trends that constructed the reality about the causes for young women's choices of careers. I then used that newly constructed reality as a baseline to develop the programme that would respond positively to assist young women to freely choose careers that are dear to them without any contextual factors.

Hazari *et al*. (2017:1) highlight the importance of the use of mixed methods where hypotheses need to be tested in both quantitative and qualitative methods, by reporting that although research was conducted on the effect of a few peers/classmates on students' educational outcomes, as explained in chapter two of this research, the collective effect of peers in science classroom environments has not yet been largely researched through quantitative methods. Qualitative research has been undertaken and demonstrated the ways in which peers in a classroom environment can 'facilitate or inhibit students' identifying with science'. This argument presented the need for these authors to do the same research with a different method. That encouraged me to identify factors using both methods because one method alone would not reach a conclusion.

4.5 POPULATION AND SAMPLING

4.5.1 Population

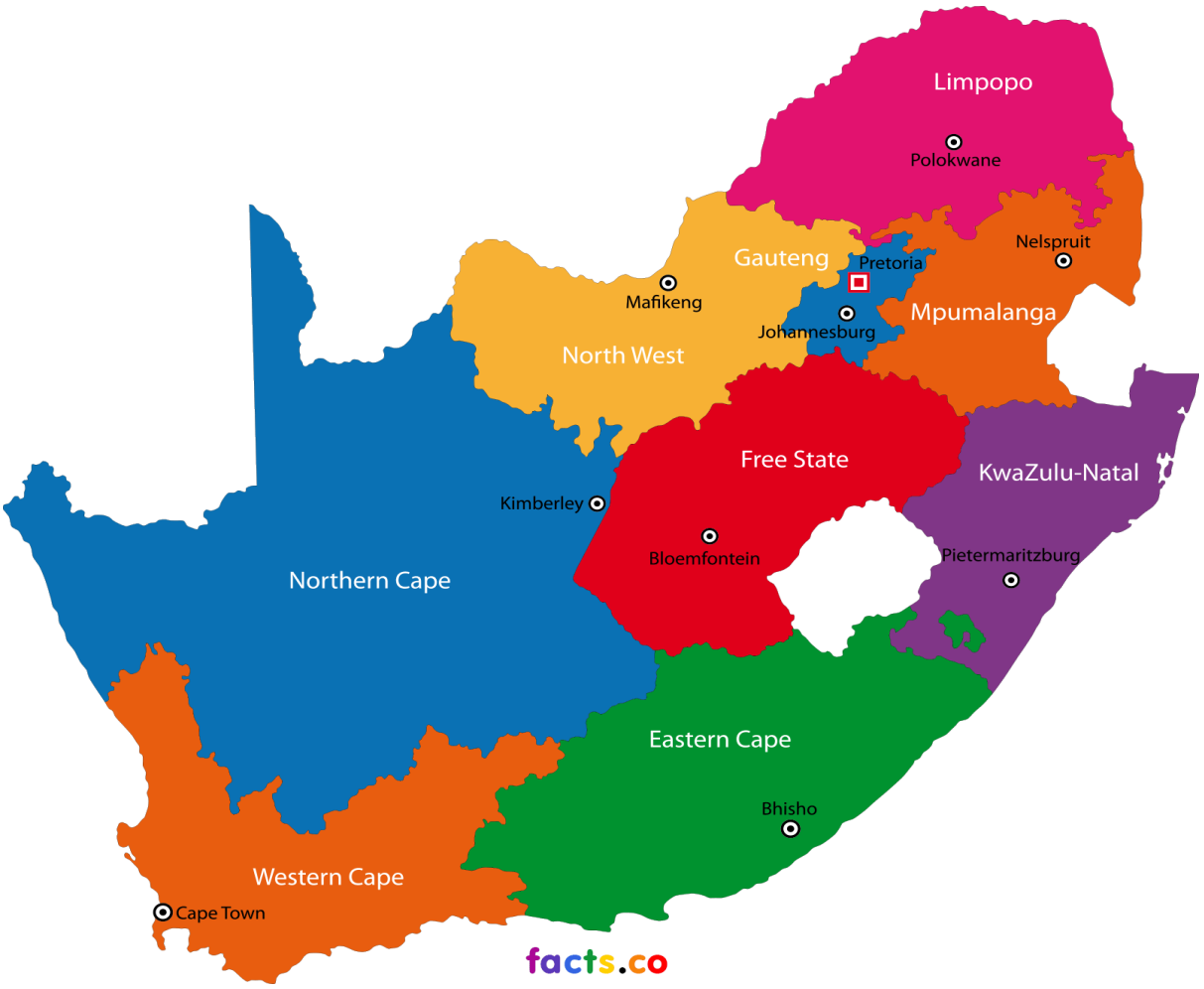
Taylor (2005:186) explains population as a collection of all the elements that are being studied and about which the researcher is trying to draw conclusions. A collection of

only some of those elements is a sample hence the two are relative concepts. Therefore, a sample has to be a representation of a population.

This study focused on young students who are between 18 and 35 years of age, registered in the STEM fields in South African universities as well as their lecturers, the administrators responsible for student admissions and government officials who are involved in the career choices of university students. I selected two South African universities where the study was conducted to investigate what influences the choice of careers of young women in South African universities, which results in their low numbers in the STEM fields. These two universities are found in different provinces, adjacent to each other and holding completely diverse historical backgrounds. University 1 is historically a distance learning institution, in a different province than the other. It services not only South Africans but Africans and students in other parts of the world. On the other hand, university 2 previously served white South Africans only, with Afrikaans as the main medium of instruction. This university is currently undergoing transformation in terms of the language of instruction and a number of other progressive issues.

The aim for this population was to ensure that there were very few, if any, similarities in the institutional cultures in general and in particular regarding career choices of the female students. That factor assisted me to gather data which was independent for each university and was free from influence of the other. The number of universities selected is also fair for representation in this research and its findings, considering the total number of universities in the country, i.e. twenty-five (25), which are also found in different provinces across the country.

Map 1: Provinces of the Republic of South Africa showing location of two participating universities



What was also important about these universities was the fact that in one university, lecturers have direct contact with the students and the manner of content delivery is basically face-to-face. In the other, the delivery of content is online and students can only meet with their lecturers if arranged and that is not necessarily an opportunity enjoyed by all students, especially those who are out of the country. The findings of this research showed that, even the manner in which the STEM content is delivered, different as they are in these two institutions, does not have an impact on the performance of either young men or young women. Hence the two participating STEM lecturers agreed that there is no difference in the performance of those two youth groups.

The third institution which was also included as part of the Population is the government department, working closely with universities, supporting them in their mandate of higher education delivery in the country. The aim was to establish if there were dedicated programmes for young women's development in general and in particular, that encourage young women to take up careers in the STEM fields. If there were such programmes, collaboration with other relevant stakeholders in the implementation, would have been the approach of this research. In the absence of such programmes, the approach would change and be to develop an appropriate programme that would encourage young women to participate more in the STEM fields in South African universities.

4.5.2 Sampling

Choosing a research sample is a very important step of the research. The aim is to draw a representative sample from the population, in order to realise the aim of the study. Equally, selection of the appropriate sampling technique depends on the aim of the study. Tashakkori and Teddlie (2003:715) explain sampling as the selection of items or entities such as people, groups, settings, etc. for analysis, in a way that will maximise the researcher's ability to answer the research questions. In support of this explanation California State University, Northridge (CSUN, 22-23), clarifies that, a number of quantitative researchers tend to use the probability sampling technique, which is based on the mathematical theory of probability. In this type of technique, each unit of the population has a specifiable chance of being selected, with the motive of generating a sample that is representative of the population in which it was drawn.

For the quantitative part of this study, the probability sampling technique was used. I specifically identified the STEM fields' students as participants, who had the probability of providing the right answers to the research questions. Although the purpose of this study was to improve the numbers of young women in the STEM, young men were also requested to complete the questionnaire as their reasons for choosing careers in the STEM fields were to be compared with those of young women to determine why more young men choose these careers than their female counterparts. That information was then used to develop a young women-specific programme as a goal of this study.

Subsequently, the selection of 120 students to complete the questionnaire was done randomly, taking tune from an explanation by Marshall (1996: 522), that, in a random sampling, the nature of population is defined and all members have an equal chance of selection. Since the STEM fields were a specifically defined area of research, where sampling population was to be drawn from, I was confident that those randomly selected participants had a high probability of providing accurate information required for this research. For example, one of the questions from the questionnaire asked the participating students if the career which they were studying then was their first choice. The responses would provide useful information for this study, only if the participants were studying the STEM fields, irrespective of whether they would be positive or negative.

As indicated in the paragraphs below, the initial number of students decided upon was 120, with 60 of them coming from each participating university, considering the sub-fields that are made by the STEM fields, i.e. science, technology, engineering and mathematics. Although the responses came from 100 students in all, that was a fair number for me to make conclusions based on their responses. That decision was supported by Marshall (1996:522) when further indicating that the size of the sample is determined by an ideal number necessary to enable valid insinuations to be made about the population. The targeted sample size also depends upon the parameters of the phenomenon under study.

For the qualitative part of this study, purposive sampling technique was selected based on the definition given by Creswell *et al*. (2010:79). It is the sampling approach whereby participants are selected because of the data they have or represent. This is the kind of data necessary for the study. Therefore, sampling decisions are made for the purpose of obtaining the richest possible source of information to answer the research questions.

Marshall (1996:523) supports this explanation of what he also refers to as a judgement sampling technique, i.e. that the researcher purposefully selects the most productive sample to respond to research questions. In some cases, researchers involve 'developing a framework of the variables', such as age, social class and gender, in

order to influence the individual's contribution, depending on the researcher's background knowledge of the research area. Macmillan and Schumacher (2010:138) justify the above information by stating that the researcher's selection of certain elements is based on his/her knowledge of the population. This means a judgement is made about which subjects should be selected to provide the best information to address the purpose of the research. These authors (2010:328) also add that the size of a sample depends on the purpose, the research problem, the major data collection strategy and the availability of information.

In view of this information, the STEM lecturers, female STEM students and government senior managers (officials) whose programmes were directly linked to supporting universities, were selected for interviews. In the case of the lecturers and officials, work experience in terms of positions occupied, was important since their level of authority would grant me the right answers for the research questions. The STEM lecturers have the authority to determine the performance of their students, irrespective of their gender. For instance, one of the interview questions for the lecturers was whether there was a difference between the performance of female and male students in the STEM subjects. If the answers were positive, that female students perform generally poor in the STEM, that would lead the study to a conclusion that, the STEM fields were meant for men and not for women. In the case where the answers were negative, the study would then come to a conclusion that, there were other reasons besides young women's natural makeup, that influenced them not to choose such careers and therefore find out such reasons.

Government officials who are senior managers know the programmes they are responsible for. For this study, they were requested to mention the programmes that were supporting the development of students at universities. In addition to that, they were asked about the programmes that were meant to empower female students and in particular, programmes that were dedicated to the development of female students within the STEM fields. If such programmes were in place, the study would want to determine the reasons for young women to not take advantage of such. If such programmes were not there, this research would then determine the reasons and also conclude in working towards the development of such a programme.

Regarding the STEM students, I wanted the females to present the life experiences that had influenced them to take up careers in those fields. They would present those experiences that might be hindrances for other young women to choose careers in the same fields as them. One of the questions asked was why they had chosen a career in the STEM fields. The answers would be used to determine if young women face work difficulties within the STEM fields or from the families and communities where they come from. Answers would then determine the kind of a programme that this study would have to developed, as well as the target, e.g. community-based, sector- based or any other type of programmes.

Denzin and Lincoln (2000:370) support the above by emphasizing that a number of qualitative researchers choose the purposive instead of random sampling method since they seek out people, groups, individuals and settings where the processes being studied are most likely to occur. In agreement, Terre Blanche *et al*. (2011:49) also report that sampling is the selection of participants for the research among the whole population. This involves a decision to be made about which people may be relevant for the study, their behaviour, the set-up and events around them that need to be observed. The intention here was to select a sample that would represent the population that the researcher wanted to investigate and draw conclusions. Therefore, sampling for this study was as follows:

- One hundred (120) university students (60 from each) in the STEM subjects were requested to complete the first questionnaire and there were one hundred (100) responses.
- Fifteen (10) lecturers (5 from each university) in the STEM subjects were requested to complete the second and different questionnaire and there were four (4) responses.
- Two student (2) admissions administrators, (1 from each university) were requested to complete the third and different questionnaire and the response came from only one (1).
- Information on the numbers of young women who were registered in the STEM fields against those who were registered in the social fields between 2015 and 2016 was requested from the offices of student admission administrators of the two universities.

- Two (2) young female university students (1 from each university) who were involved with the STEM fields were interviewed.
- Two (2) lecturers (1 female and 1 male), 1 from each university, who were involved with the STEM fields were interviewed.
- Two (2) officials (1 female and 1 male), from the participating government department whose performance agreements were related to the issues in this study were interviewed.

Table 2: Sampling

Institutions	**Students**	**Staff members**
Institution 1: interviewed	1	1 lecturer
Institution 2: interviewed	1	1 lecturer
Institution 3: interviewed	N/A	2 officials
Institution 1: completed questionnaires	58	3 lecturers
Institution 2: completed questionnaires	42	1 lecturer
Institution 1: completed questionnaires	N/A	1 admissions administrator
Total of all participants	**102**	**09**
Grand total: Participants		**111**

4.6 INSTRUMENTATION AND DATA COLLECTION TECHNIQUES

4.6.1 Research designs

A research design is a collection of various processes that researchers engage on, to collect, analyse, interpret and present the research data. A research design guides the methods to be used in a study and the decisions that a researcher should take during and after the collection of data and determines the logic to be used for the interpretation of such data. Designs are therefore important and, in a way, lay the foundation for the research findings (Creswell & Clark, 2007:58). In other words, as emphasized by Macmillan and Schumacher (2010:20), research designs should explain the period or the time when data is collected, the nature of participants and the surroundings within which data will be obtained.

In this study, data was partly collected from university students, who had already

chosen the STEM fields as a career in order to ascertain whether taking that decision was a challenge. Having experienced these fields at a higher level, the question was asked whether they would encourage others to do so and also to check if they had no regrets. This was based on the research conducted earlier, showing that women tend to regret having joined the STEM fields and ultimately leave these fields as a result of the chilly environment around them (Ureksoy, 2011:6,8). The studies on post-secondary attrition conducted by Erwin and Maurutto (1998:52) showed that female science undergraduate students were almost as numerous as their male counterparts. However, at higher levels female student numbers decline, as if the undergraduate level is their decision-making stage to leave the sciences.

Convergent sequential mixed method was used in this study. For the quantitative aspect, the means for data collection was done through questionnaires and for the qualitative method, interviews were conducted. The concurrent, triangulation design was implemented as data was collected in both quantitative and qualitative methods, at the same time, i.e. while questionnaires were distributed to the participants and responses awaited, I continued to conduct interviews because there was a delay in the return of responses from some participants. However, the interpretation of data collected through both methods was done simultaneously. In his doctoral thesis, Tirfe (2016:122–3) quoted the explanation given by Creswell and Clark (2007:85) that the mixed method research design is divided into six categories: (i) sequential explanatory design; (ii) sequential exploratory design; (iii) sequential transformative design; (iv) concurrent nested design; (v) concurrent transformative design; and (vi) concurrent triangulation design. They differ from each other as explained in the following sections.

4.6.1.1 Sequential explanatory design

Here, data is collected quantitatively, e.g. through the use of questionnaires, and also analysed through the same method. Thereafter, more data is collected through the qualitative method, e.g. by conducting interviews as well as analysing such through the same method. Interpretation of all data collected will then take place during the last phase. In this case, data collected and analysed qualitatively, is used to clarify the results of the quantitative method.

4.6.1.2 Sequential exploratory design

The purpose of this design is to use the results of the quantitative method to clarify those of the qualitative method. This works differently from the above design in that data is collected and analysed qualitatively first and thereafter, quantitatively. The findings will then be integrated for interpretation.

4.6.1.3 Sequential transformative design

This design makes use of theories, like feminism, racism, classism, etc. to inform the kinds of methods that the researcher should use. The method used should suit the kind of theory used, not the other way around.

4.6.1.4 Concurrent transformative design

This design also conforms to the theory selected for the study, ensuring that the method used for the study suits its theoretical perspective. Data collection for both qualitative and quantitative methods is done in the same phase. Interpretation also embraces the findings of both methods in the same phase.

4.6.1.5 Concurrent embedded/nested design

Here data collected qualitatively and quantitatively is processed in the same phase. Data collected qualitatively is used to understand that which was collected quantitatively. The themes under which data is collected may be the same or even differ. Interpretation of data will then be managed at the same time, side by side.

4.6.1.6 Concurrent triangulation design

This design is normally used by most mixed method researchers, where data collection is done concurrently, i.e. in the same phase, in both the quantitative and qualitative manner. Although the quantitative method of data collection is normally given priority, there are no restrictions as to which must come first. During the interpretation phase, integration of the findings is also implemented. This design was selected for this study, since it was difficult to schedule interviews after the collection of questionnaires. Interview schedules depended mostly on the times allocated by the participants. On the other hand, the questionnaire respondents did not complete and return the questionnaire at the same time, which was going to take a lot of valuable time.

4.6.2 Research methods

4.6.2.1 Quantitative method

According to Marshall (1996: 522), the researcher's choice of the research method does not depend on his/her preference. It lies on the type of the research to be conducted. The main purpose of taking the quantitative approach in research is to test the pre-determined hypotheses, with the aim of producing a generalisable body of information. Studies of this nature are important in answering more mechanistic 'what' questions. On the opposite side, qualitative studies tend to provide clarification and an insight on the 'complex psychosocial issues', through humanistic questions such as, 'why' and 'how' (Marshall, 1996:522).

There was a need to implement the quantitative method because I was already aware of the 'pre-determined hypothesis', that, the number of young women is higher than that of young men in higher education institutions in South Africa. However, young women's numbers are significantly low in the STEM fields, in those institutions. So, for this research, besides the abovementioned situation of young women, numbers were very important as they were at the centre of the hypothesis. Before I could understand the reasons that caused this disparity, as a researcher, I had to verify that information, which dictated the quantitative method right from the beginning of this study. Secondly, the aim of this research determined working with numbers, which also directed to the qualitative research method.

This method added a lot of value to this study since the number of young women in the STEM career fields in the researched universities were acquired and compared to that of young women who were enrolled in the social fields. To conduct the survey, questionnaires were used to determine what might inform a relevant and responsive programme, to encourage more young women to participate in the STEM fields than it was the case. That was necessary for this study since social transformation is a dependent variable of economic empowerment. In the same way, balancing between STEM and social fields in South African universities is a dependent variable to socioeconomic sustainability.

As indicated under sampling, the respondents of questionnaires were far more than the participants who were interviewed. This is supported by Erwin and Maurutto (1998:56) when they state that questionnaires are critical for covering socio-demographics. Davies (2007:82) adds to that by highlighting that questionnaires are intended to facilitate communication, are usually brief but always driven by the researcher's own agenda. The responses provided should be treated as absolute, which assists the researcher to take decisions after considering them and the responses from a number of other questionnaires. In this study, the respondents to three different questionnaires were participants from different sectors within the STEM and university spheres, i.e. lecturers, students and administrator, who in their areas of operation managed to provide supplementary information that matched and contributed towards the research outcome.

4.6.2.2 Qualitative method

In addition to the quantitative method of data collection, there was a need for the use of qualitative method as well. This study had to find the in-depth understanding on all aspects, including the experiences of young women as well as the way they are perceived by society that influences their choice of careers, resulting in most of them choosing careers in the social fields and few in the STEM fields. Therefore, interviews were conducted as part of the data collection method.

According to Grix (2010:120-121), qualitative researchers work as philosophical interpreters, using methods that generate data as well as those that are flexible and sensitive to the social context in which data are produced. On the other hand, Naoum (2013:41) reports that this method is perceived to be subjective in nature since it emphasizes meanings, experiences, descriptions, etc. and is often verbally given, i.e. through interviews. Creswell *et al*. *(*2010) explain an interview as a two-way conversation in which the interviewer asks the participant or interviewee questions as a way of collecting data and learning about the ideologies, beliefs, opinions and behaviours of the participant in order to understand the world in which the participant lives. This study had to find out if young people in general and young women in particular, were aware of the skills that were critical to the economic market of the country as well as the fact that their socioeconomic empowerment is necessary for

their attainment of sustainable/holistic youth development. If these concerns were proved to be positive, i.e. young people were aware of them, it would mean that the reasons for young women choosing careers other than the STEM fields are caused by social stereotypes that these fields are meant for men and not for women. Semi-structured interviews were conducted as part of data collection for this study, as I wanted to understand the behaviours of young women, within the themes that were generated ahead of the interviews. However, this type of interview allowed the participants to provide more in-depth information guided by probing questions where they seemed to be derailing from the intended themes.

In their research, which is closely related to this study, based on their concerns about the lower number of young women in the STEM fields, Erwin and Maurutto (1998:56) used in-depth semi-structured interviews to explore the perceptions and principles to disclose the social concepts, experiences, beliefs and systems that influenced young women's behaviour and expectations of universities as well as their gender relations. However, Bryman (2004:319–21) argues that unstructured interviews are open-ended, in-depth and designed to obtain detailed data from a participant using follow-up questions while semi-structured interviews are a method of understanding the behaviours of people without classifying them in advance, which could limit the scope of the research.

Davies (2007:29) states that semi-structured interviews stimulate reflection and exploration. As a result, the questions have to be simple. He claims that an interview is a tool concerned with people's feelings and that it is good at enabling the researcher to learn, at first-hand, about people's perspectives on the subject chosen as the project's focus. It can therefore lead to significant advances in the theoretical understanding of a social reality.

Davies (2007:30) maintains that group interviews are used to identify trends of thoughts and feelings among the interviewees; the researcher's own views should never become obvious. In summary, McMillan and Schumacher (2010) regard interviews in general as enabling the researcher to obtain information on how the participants perceive their world and how they explain and understand important events that are happening in their lives.

4.7 DATA ANALYSIS AND INTERPRETATION METHODS

4.7.1 Deductive

For quantitative method, analysis of data was done from the general views and responses to questionnaires on the questions asked and comments made, e.g. this comment: ‘Most young women choose careers in the social fields and few choose from the STEM fields’, was analysed as ‘Young women prefer social rather than STEM fields as careers’. Such analysis and interpretation helped me to understand the situation as it is and I then sought further explanation to determine the cause of that situation.

Creswell (2014:93) explains that in quantitative studies, one uses theory deductively and places it at the beginning of the proposed study. In this case, the researcher advances a theory, collects data to test it and reflects on its confirmation or disconfirmation by the results, with the aim of testing or verifying a theory rather than developing it. The theory turns out to be the framework of the entire study, an organizing model for the research questions or hypotheses and for the data collection procedure. The researcher tests or verifies a theory by examining hypotheses or questions derived from it. These hypotheses or questions contain variables or constructs that the researcher needs to define. Therefore, the researcher locates an instrument to be used in order to measure or observe the attitudes or behaviours of participants in a study. Finally, the researcher collects scores on these instruments to confirm or disconfirm the theory.

The best advice, as provided by Creswell (2014:93), is to introduce the theory early, whilst planning the study, i.e. in the introduction, in the literature review section, immediately after stating the hypotheses or research questions, to ensure that there are connections among the variables. He also advises (2014:95) that theory be identified in advance to explain the relationship between independent and dependent variables.

The theory that I advanced in this study, as a result of the gender disparity in the STEM fields, was prompted by the negative sex-based stereotypes, mentioned in the introductory section of this study, which were going to be tested through the use of

questionnaires. The findings of different studies like that of Reubena *et al*. (2014:1403) were consulted and their report states that women outnumber men in undergraduate enrolments in the US whereas very few of them major in mathematics or science subjects. Such reports planted the seed of both feminism and sexism as theories that were suitable for my study, which would better be proven wrong or right by the findings of this research. The questions that I developed for questionnaires were categorised according to themes derived from the research question for this study. For example, under the theme: 'University education', one of the questions that the respondents had to answer, by agreeing or disagreeing was: Your university has a role to play in improving the participation of young women in the STEM fields.

4.7.2 Inductive

For qualitative research, the interview results of individual young women helped me to understand what influenced most of them, as this was revealed by the pattern of their responses to the same questions, e.g. Why did you choose the STEM fields as your career and not any other field?

Davies (2007:10) says that qualitative research involves an interpretive and naturalistic approach to the world. This means that qualitative researchers study things in their natural setting, attempting to make sense of or to interpret phenomena in terms of the meaning people bring to them. As mentioned in the introduction of this study, experience had taught me that there were more girls than boys in both primary and secondary schools. This was confirmed by a number of researchers. What I did not understand was that even in institutions of higher learning, young women were still in the majority although their numbers were significantly low in the STEM fields, which are critical to the labour market and their economic emancipation.

The interpretive paradigm became the most suitable choice for the qualitative method since it was necessary for me to interpret data collected and presented in the social context of the participants. For example, to understand whether the choice of careers of young women in South African universities is influenced by their nature based on general social expectation, cultural beliefs, economic values or any other aspect, that would have been presented during data collection processes.

The inductive analysis of data is a process where data is organised into categories and then patterns of these categories are identified (Le Compte, 2000). This method seeks to demonstrate the meaning of written or visual material by allocating their content systematically in order to pre-determine the detailed categories, quantifying and interpreting the outcomes (Payne & Payne, 2004). Data analysis is an ongoing process, comprising integrating the data collection, processing, analysing and reporting. All data that has been collected, either electronically or digitally, should be transcribed. This is the function of the researcher as this may need to be strengthened with, for instance, non-verbal cues and silent moments during engagement with the participants, which may attach meaning to the behaviour of the participants, like emotional distress or expression of any other gesture (Creswell *et al*., 2010:105). This was evident during an interview with a young woman who became emotional when responding to the question why she chose a career in the STEM fields. She became emotional when explaining that she wanted to be a doctor but did not have sufficient funding. As a result, she became a STEM teacher, which was a consolation for her. My interpretation to this was that the STEM fields are more expensive than some of the social sciences; hence most young women flock to these fields.

Terre Blanche *et al*. (2006:7) find that interpretive and constructionist research is linked to the inductive approach because the researcher starts with a vaguely speculative research question. Thereafter, the researcher will try to put meaning to the phenomenon by observing a set of particular instances or occurrences. After conducting the first set of interviews common trends, patterns and themes emerge and a second set of interviews may be conducted, based on the developed theory and understanding. Subsequently, more focused and refined interviews will provide a deeper understanding of the subject.

I concur with this approach because during the first set of interviews, it almost felt as if my questions would not provide me with relevant answers and that the time allocated, i.e. 30–40 minutes was too lengthy. That perception changed as I asked probing questions to the answers that were provided to obtain more information. I found that the more information I got the more adequate was the time frame.

For data analysis, I used a coding system. Creswell *et al*. *(*2010:105) define it as the marking of segments of data with symbols, descriptive words or unique identifying

names. The process of coding enables the researcher to retrieve and rapidly collect together all the text and other data that is associated with some thematic ideas, in order that the sorted bits can be examined together and different cases may be compared. In this study, data collected was also sorted according to the four themes developed for questionnaires and interviews: (i) youth development; (ii) economic empowerment and social transformation; (iii) career choice; and, (iv) university education. Under each theme there were four to five questions. Therefore, within each category there were more codes that represented each question. That made analysis easier to handle.

4.7.3 Document analysis

Another technique used in this study was document analysis since I had requested documents from participating institutions, to establish how the planned awareness programme could fit into those already existing and also to check if partnership in implementing them was possible. From the documents that were collected and analysed, it was clear that good plans were in place but not yet implemented. This helped me to identify gaps as well as plan on how those would be closed as an outcome of this study. Some areas needed to be strengthened as they were talking about improving the participation of women in the academic world but not necessarily young women. Moreover, the issue of improving participation of young women in the STEM fields did not feature anywhere in the documents. That confirmed the need for this study and its ultimate awareness programme.

In her doctoral thesis, Mokhele (2011:96–97) mentions that document analysis is classified as probably one of the most important research techniques in the social sciences. It can also be referred to as content analysis. Here, the analyst views data as representative texts, images, and expressions that are created to be seen, read, interpreted, and acted upon, in order to find their meanings. As Cohen, Manion and Morrison (2007) add, content analysis can therefore be defined as summarisation of, or reporting of, written data, its key messages and the main contents thereof. Krippendorp (2004:18) further alludes to the fact that this research technique can be used to make replicable and valid inferences from texts or ‘other meaningful matter’. It can also be used to analyse interview transcripts and media products. Regrettably, an observation has been made that there are a number of official documents in

different organisations, in the form of minutes with important resolutions from meetings, reports with necessary information etc, that are abundant (Mokhele, 2011: 96–97). I believe such documents contain the institutional memories of most organisations and employees need to be made aware of such information.

For this study, the documents that were significant for the analysis that would add value in this study were, an email from university 1, with a table, populated with statistical information (2015-2016), extracted from the HEMIS submission to the Department of Higher Education and Training; the Staffing South Africa's Universities Framework (DHET, 2015); and the Ministerial Statement on the Implementation of the University Capacity Development Programme through Effective Management and Utilisation of the University Capacity Development Grant 2018-2020 (DHET, 2017). In some cases, the interviewees made me aware of such documents by referring to them from time to time, which triggered my interest to find, read and analyse as part of this research. For instance, one of the documents with which I was provided, revealed sound plans by an institution, which have unfortunately not yet been fully implemented due to budgetary constraints. That fact contributed to the final product of this study in terms of the structure of a programme and also shed light on other factors that may need to be researched beyond this study.

4.8 VALIDITY AND RELIABILITY/CREDIBILITY AND TRUSTWORTHINESS

Creswell et al. (2010) comment that the validity and reliability of qualitative research normally refers to its credibility, or lack of it. Merriam (1998) agrees with this statement, that validity and reliability may not be used for qualitative research studies but instead the more appropriate terms to be used are the trustworthiness and credibility of the data.

4.8.1 Validity and reliability

Validity and reliability are like yardsticks used to measure and actually ensure that a study's results remain valuable and reliable. Joppe (2000:1) explains validity through its function of determining whether the research truly measures that which it was intended to measure or how truthful the research results are. On reliability, Joppe (2000) describes it as the extent to which results are consistent over time and if the

same results of a study can be reproduced under similar conditions should the research be repeated.

For validity determination, I have ensured that my study results can be generalised and are the same after using a positivist (traditional and quantitative) design as this interpretivist one, i.e. interpreting the data collected and presenting it in the social context of the participants. When analysing the data collected through interviews, I have ensured that my interpretation of what has been said by participants can later be verified by replaying the tape recorder which was used to record interviews. Where the meaning seemed ambiguous or not clear, follow-up discussions with the participants were held.

Taylor (2005:254–55) considers that validating and establishing instruments is a necessity for quantitative research. The use of standardised instruments is recommended since validity and reliability are already established. For instance, descriptive and inferential statistics are used when analysing data, like graphs and percentages. The analysis of data in this study was done by comparing the percentages of young women who are registered in the STEM fields with those who registered in the social sciences. This was also presented in a graph, in order to display the true picture of what led to the aim of this study and the development of a responsive programme to remedy that situation.

4.9 RESEARCH ETHICS

According to Terre Blanche *et al*. (2006:61–2), research ethics should always be borne in mind by social researchers and be considered when planning, designing, implementing and reporting researches where human beings are participants. The reason for this concern, which also led to the development of ethical guidelines, was because some researchers abused research participants by breaking their trust in different ways. In some instances, researchers would, without permission, reveal private information, e.g. the participants' car registration numbers in a video recording, as part of their profiles.

Ethics, as explained by McMillan and Schumacher (2010), is generally concerned with 'beliefs about what is morally right or wrong'. Research ethics focus on what is morally

appropriate or inappropriate when collecting data from participants or when accessing archival data. This includes confidentiality, which means that no one should have access to participants' information including their names except for the researcher. The researcher should also thoroughly explain to the participants the processes of the research and be frank and honest about all aspects of the study (McMillan & Schumacher, 2010).

Aldridge and Levine (2001:23) point out that sensitivity needs to be applied in the use of language, especially with regard to age, race, ethnicity, gender and disability. This research was sensitive to the values of participants by protecting their private information and behaviour during interviews and contact sessions, which may be offensive to them or even to the readers. Since it was anticipated that this research might touch on issues of culture and tradition when investigating whether young women's choice of careers is based on patriarchal ideologies that certain careers are not meant for women, the language used was non-sexist. I used gender-neutral words and phrases instead of gender-biased language, since gender issues feature throughout the research. For instance, as proposed by Henning, Gravett and Van Rensburg (2002:122–23), instead of using the word manpower, I used a substitute, i.e. workforce, which appears a number of times in the study. I also adopted a polite approach by using plural words for explanations in order to avoid pinpointing specific participants, e.g. thoughtful students do research before choosing careers that are scarce in the market.

Permission to conduct interviews and complete questionnaires was sought and granted by the institutions that participated in this study (refer to Appendices). Thereafter, I requested appointments with the targeted individuals for interviews according to the preference of the participants. Before interviews were conducted, participants were given consent forms to sign, informing them of the steps that would be followed in the research, especially during the contact sessions. In the same manner, I also sent consent forms to prospective respondents for the questionnaire, outlining the rights and expectations in completing it. Bulger (2004) defines informed consent as a process in which participants give their consent to participate in a research project after being informed of its procedures, risks and benefits. This author is supported by McMillan and Schumacher (2010) who suggest and explain further

that researchers should be open and frank about the purpose of the research and should fully disclose its processes.

According to Davies (2007:46), the other aspect of ethics in research is ensuring that the researcher him/herself is not at risk, including the researcher's university. This includes the intellectual property that the researcher is developing to become an end-product, which is in some degree commercially marketable, with rights belonging to him/her.

4.10 SUMMARY

This chapter focused mainly on the instruments and methods that I used to conduct the study under the guidance of experts in such fields. Precautions were taken to ensure that aspects of both quantitative and qualitative approaches are implemented, in order to comply with the principles of the selected mixed method. The results of some instruments, e.g. reliability of the study, are presented in the form of tables and graphs, which displayed scientific analysis that can be tested further in the future. The next chapter is important and should be read in relation to this one, in order to reconcile the stated theory and its practicality.

CHAPTER FIVE

DATA ANALYSIS

5.1 INTRODUCTION

Chapters two, three and four were used as a basis for the compilation of chapter five. Data collected through interviews, questionnaires and from documents were compared to the literature review, theoretical framework, research design and methodology in those chapters. This chapter reveals the perceptions of young students and lecturers in the STEM fields at different universities, student admission administrators and government officials who deal directly with universities. Some findings were derived from documents developed by participating universities and the government department around the participation of young women in the STEM fields.

What stood out clearly in the findings of this research was that most participants were aware that the number of young women is indeed significantly lower than that of their male counterparts in the STEM fields in South African universities (see Figure 5). This means that they were aware that the STEM fields were still male dominated at the time of this study. However, some participants were hoping that at some stage something would be done to address that situation, even though they had never actively engaged or raised awareness on this issue. Through this study, most participants made a contribution towards the recommendations in this chapter (see Figures 2 to 5).

The questions for interviews and questionnaires were categorised in the same way, according to themes i.e. youth development; economic empowerment and social transformation; career choice; university education and developmental programmes. Each category comprised a number of questions, which led to responses that addressed what I wanted to reveal regarding the five topics. The questions were the same in both these instruments except with regard to different occupations of the interviewees and respondents, e.g. under University Education, a question for the STEM lecturers was: 'Was the career field in which you are working, your first choice?' For the students, the same question was phrased differently: Was the career field in which you are studying your first choice?' The other difference between these instruments was the manner in which responses were expected, whereby interviewees

were to answer verbally and as extensively as they could whilst the questionnaire respondents were limited in certain questions as they had to put a mark against the symbol that best represented their views. However, there were spaces provided in the last category of questions which allowed them to substantiate their responses.

5.2 DATA ANALYSIS

Data was collected by means of interviews, questionnaires and document analysis. By request, documents regarding the registration of young women in the STEM and humanities (social) fields were made available. Data from both the questionnaires and the interviews were also analysed using a thematic coding approach with responses categorised according to evolving themes using an inductive approach and thematic examination. The themes were the same for both instruments since the enquiry was to obtain the same information.

For quantitative part of the research, data was analysed deductively, whereby the theories that were adopted and discussed from the introduction of the study, to literature review, onwards, were being tested. The theory that gender disparity in the STEM fields could be as a result of the negative sex-based stereotypes, were then tested through the responses from the questionnaires. There, I aligned my study with what Creswell (2014: 32) explains, i.e. quantitative researchers build in protections against bias, control alternative explanations, in order to generalize and replicate the findings, e.g. the view mentioned earlier in the study, that most young women choose careers in the social fields and few choose from the STEM fields was analysed through comments such as: ‘Young women prefer social rather than STEM fields as careers’. Such responses sufficed for analysis and interpretation needed for the quantitative explanation of this study, but since the mixed method approach was selected, concurrent processes were taking place to cover the qualitative side.

Qualitatively, I analysed data inductively, whereby themes got built from particular to the general state and interpretations on the meaning of the analysed data were made. That, led to the development of an awareness programme, based on the findings, as advised by Creswell (2014:32). For example, under the theme ‘Youth Development’, one of the questions was, whether girls and boys, young women and young men were equally developed through relevant programmes in South Africa, the score was 97

respondents, with the mean value of 2,95 and 1,09 standard deviation. Here, a higher number of respondents were not sure, followed by those who disagreed. This served as a need for advocacy, to raise awareness of the gap in the development of girls and young women, in the STEM fields, as per the findings of this study.

5.3 RESULTS OF RESEARCH

5.3.1 Questionnaires: representation and analysis

Questionnaires were of three kinds but differed slightly, mostly in wording, to accommodate the different occupations of the respondents, e.g. the wording on the questionnaire for students: 'The career field in which you are currently studying…?' was changed for lecturers to 'The career field in which you are currently working...?'

There was a questionnaire for STEM lecturers, completed by four (4) lecturers from both universities and a questionnaire for STEM students, completed by one hundred (100) students from both universities. The questionnaire for administrators, completed by one (1) administrator, had certain questions that were meant only for them, based on the work they do, which is completely different from that of lecturers or the role of students, e.g. 'What is the average percentage of young female students who registered to study careers in the STEM fields in the last three years, including 2017?', i.e. 2015 to 2017.

5.3.1.1 Biographical information: Section A

The first section of all questionnaires, i.e. Section A, consisted of biographical information that required the basic profile of respondents. As indicated in chapter three, this study included both male and female students for the completion of the students' questionnaire. It was important, especially for the outcome of this study, since young men have mothers, sisters, female friends, etc. As for lecturers and the administrator, they were both male and female. This assisted me in getting opinions from both genders. Raising awareness in society and communities on any subject is better done if it is inclusive of persons of different genders, races, classes, etc. The awareness programme that has been developed in chapter six is meant for people from all sectors who also need to pass the message on to the beneficiaries, i.e. young women, who might have missed it.

SECTION A: Biographical Information

Table 3: Gender (students)

Male	57
Female	43
Other	0
Total respondents	**100**

Table 4: Age (students)

18 – 20	46
21 – 25	54
26 – 35	06
Total respondents	**100**

The questionnaires had questions that were also grouped according to different themes. The first category of questions was divided into four themes in Sections B, C, D and E. Each theme was presented as a sub-heading for a section, followed by related questions in a table. Here the respondents were given a scale of five items to choose from: Strongly agree (SA); Agree (A); Not sure (NS); Disagree (D); and Strongly disagree (SD). The respondents were requested to answer by marking the appropriate number in the box with an 'X', which would also indicate the extent to which they agreed/disagreed with each statement. The above scale was used for the second (Section B) to the fourth (Section E) categories of questions. The last category of questions (Section F) consisted of open-ended questions. In this case, the respondents were provided with enough space to respond through explanations and descriptions in each question. There was also a space provided for respondents to write any proposals and inputs towards the improvement of young women's participation in the STEM fields.

5.3.1.2 Youth development: Section B

The aim of this section was to determine whether young people understand the concept of youth development and what it entails. They should be aware that, based on their choices, young men have more chances for development than young women

despite the prescripts of the Constitution (1996) and other related legislation. More importantly, young women should see the need for economic empowerment as a prerequisite for social transformation, towards fulfilment of their youthful holistic/sustainable development. The graph suggests that most young people are aware of these factors, young women included. Therefore, the choice of careers of young women, away from the STEM fields, is perpetuated by other factors, which are further discussed as this chapter unfolds.

Table 5: Youth development

Item no.	Questions	N	Mean	Std. deviation
1.	Socioeconomic empowerment is a prerequisite of holistic/sustainable youth development	**99**	**2,29**	**0,92**
2.	South Africa, like the rest of the world, is experiencing socioeconomic challenges because of climate change and the security of food supply, affecting the development of young people in general	**102**	**2,10**	**1,08**
3.	Girls and boys, young women and young men, are equally developed through relevant programmes in South Africa	**97**	**2,95**	**1,09**
4.	The Constitution of the Republic of South Africa, Act 106 of 1996 promotes youth development and protects the rights of young people by all means	**96**	**2,57**	**0,98**

Table 5 indicates the degree to which the impact of socioeconomic challenges on youth development is understood by participants. The above questions link to the objective: 'To enable young women, programming, to choose careers in the STEM fields in South African universities, as an inspiration for their sustainable/holistic youth development'.

On the question of whether socioeconomic empowerment was a prerequisite of 'Holistic/Sustainable Youth Development', out of 99 respondents, the mean value and standard deviation were 2,29 and 0,92. That indicated that there was a fair understanding that in order for young people to be holistically developed, they should have been economically empowered and were leading sustainable social lives. The responses to the question, 'South Africa, like the rest of the world is experiencing socioeconomic challenges because of climate change and security of food shortage, affecting the development of young people in general', had 102 responses, with the mean value of 2,10 and standard deviation of 1.08. That meant that there was a strong belief that South Africa was indeed experiencing socioeconomic challenges that affected the development of young people negatively.

For the question on whether girls and boys, young women and young men were equally developed through relevant programmes in South Africa, the score was 97 respondents, with the mean value of 2,95 and 1,09 standard deviation. There, a higher number of respondents were not sure, followed by those who disagreed. That served as a need for advocacy, to raise awareness of the gap in the development of girls and young women, in the STEM fields, as per the findings of this study. The results of the last question under this category were, 96 respondents, mean value 2,57 and standard deviation 0,98. More respondents were not sure if the Constitution of the Republic of South Africa, Act 106 of 1996 promoted youth development and protected the rights of young people by all means. Close to that, there was uncertainty from a number of them, creating the impression that young people needed to understand the legislation that protects their rights and be able to identify gaps and/or strengths, in order for implementation to be smooth and programming to kick-off from a strong base. However, the overall result of this section was based on the fact that young people were aware of the need for their socioeconomic empowerment, which served as a prerequisite for holistic youth development.

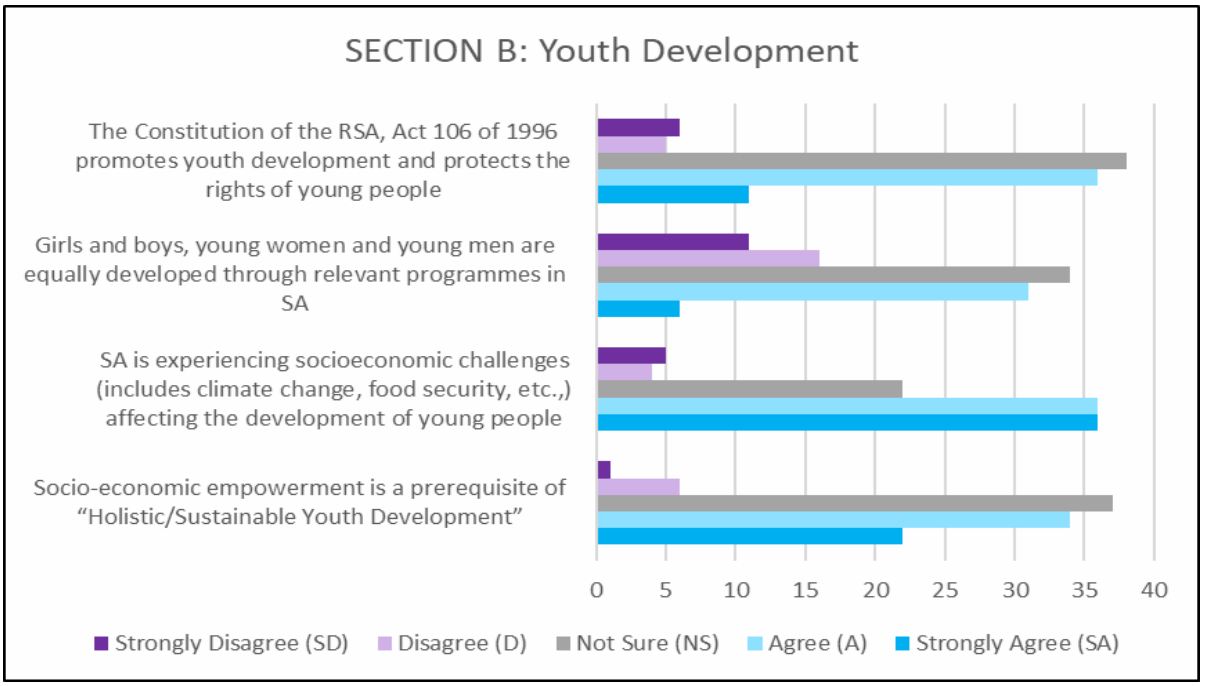


Figure 2: SECTION B: Youth Development

5.3.1.3 Economic empowerment and social transformation: Section C

In this case, young people had to be aware that they could never be socially transformed if they were not economically empowered. Therefore, their desire and need for sustainable lives and holistic youth development starts with socioeconomic empowerment. That applied to both young men and young women independently. Young women, as employees, sisters or wives cannot rely on young men to realise that. Research proved that young men were already aware of the skills that were mostly critical to the economic market of the country; hence they were participating in large numbers in the STEM. If all young people were aware of such critical and scarce skills, one might ask why young women were still flooding the social sciences and avoiding the STEM fields where they were most needed. This graph indicated that young people in general were aware of those societal needs, which suggested that their career choices were influenced by other factors besides the requirements of the economic market.

Table 6: Economic empowerment and social transformation

Item no.	Questions	N	Mean	Std. deviation
5.	Young women have more socioeconomic challenges than their male counterparts	**102**	**2,31**	**1,08**
6.	Young men are more actively involved in the economy of the country than young women	**100**	**2,54**	**1,12**
7.	Most young students at universities are aware of the skills that are said to be scarce and yet critical of improving the economy of South Africa	**101**	**2,73**	**1,03**
8.	Economic empowerment is a requirement for social transformation	**102**	**2,08**	**0,90**

Table 6 presents the degree to which participants understand the need for economic empowerment as a means to social transformation. The questions in this table link to the objective, 'To pursue young women to balance the acquisition of skills in the STEM and social science fields, for their socioeconomic empowerment'.

To the question whether young women have more socioeconomic challenges than their male counterparts, the respondents were 102, mean value was 2,31 and standard deviation 1,08. In this case, most of the respondents (mostly females) agreed with the statement, followed by those who were not sure (mostly males). The implication was that young men may not be aware of the challenges with which young women are faced and therefore develop separately and differently. This also suggested, not necessarily the uniqueness of each gender, but the gender disparity within the youth community that is expected to live together as married couples, colleagues, friends, siblings etc., which may not be corrected if not addressed. Awareness on the need for young women to cascade the STEM fields therefore, needed to be raised among all members of society, within and around universities.

The results of the question, 'Young men are more actively involved in the economy of the country than young women' were 100, mean 2,54 and standard deviation 1,12,

with most respondents in agreement. The same sentiment as the above question applied. With the question on, ‘Most young students at universities are aware of the skills that are said to be scarce and yet critical for improving the economy of South Africa’, there were 102 responses, with a mean value of 2,73 and 1,03 standard deviation. The indication there was that there was uncertainty regarding the question, adding value to the reason for the choice of careers of young women, away from the STEM fields.

The relationship between economic empowerment and social transformation was endorsed through the results in the question, ‘Economic empowerment is a requirement for social transformation’, with 102 respondents; 2,08 mean value and 0,90 standard deviation. This created the impression that social transformation would not be acquired without economic empowerment. With this baseline, the awareness programme developed as a result of this study, was expected to succeed in identifying the ways in which young women could be economically empowered. That, included their increased participation in the STEM fields, in order for them to realise social transformation and live sustainable lives. The overall results of this section prepared the ground for identified activities that were meant to improve young women’s taking up careers in the fields that were said to be critical for the economic growth of the country, the fields in which young men were already participating in large numbers, i.e. the STEM fields.

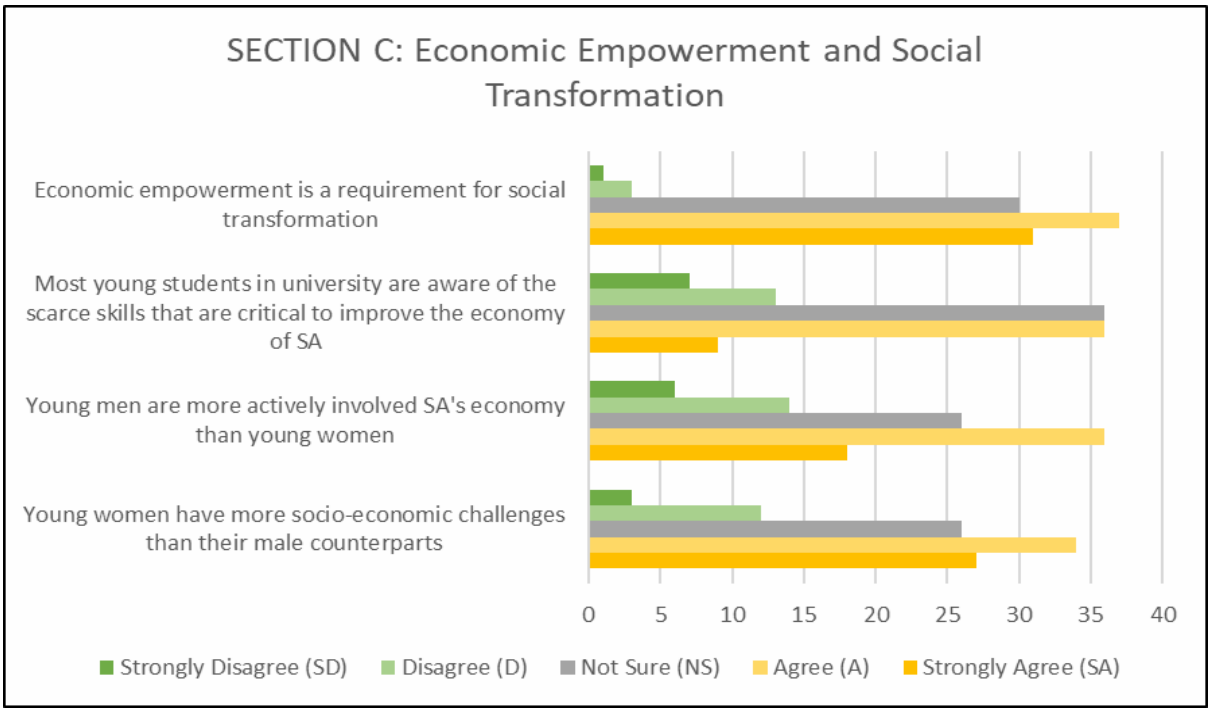


Figure 3: SECTION C: Economic Empowerment and Social Transformation

5.3.1.4 Career choice: Section D

This section wanted to establish the source of young women's choice of career since most of them were choosing careers in the health, education and welfare fields, where skills were already oversupplied, and seemed to disregarding the STEM fields where there was a shortage of young women's talent. As a result, many completed their degrees in such fields but were unable to find employment since the market was flooded. Because the graph shows that participants were aware of the benefits that the STEM fields had for young women, the main question that needed to be answered in this chapter was whether young women were afraid of being culturally ostracised or that their socialisation had an influenced in their choice of careers.

Table 7: Career choices

Item no.	Questions	N	Mean	Std. deviation
9.	Research shows that the STEM fields are dominated by men. Therefore, STEM fields are meant for men, not for women	**101**	**3,12**	**1,19**
10.	There are better career opportunities in the STEM fields than in the social sector	**102**	**2,52**	**0,89**
11.	There are no women role-models in the STEM fields who can serve as mentors to young women in South Africa	**102**	**3,17**	**0,93**
12.	Considering the number of young women who are graduates but currently unemployed, South Africa is experiencing an oversupply of jobs in certain fields and an undersupply in other fields	**103**	**2,39**	**1,18**

In Table 7 the degree to which the future of young people is influenced by career choice is displayed. The questions in this table link to the objective: 'To pursue young women to balance the acquisition of skills in the STEM and social science fields, for their socioeconomic empowerment'.

For the question: 'Research shows that the STEM fields are dominated by men. Therefore, STEM fields are meant for men, not for women', the results were: 101 responses, 3,12 mean value and 1,19 standard deviation. The implication there was that there was a great deal of uncertainty about the question. The responses in the next question, 'There are better career opportunities in the STEM fields than in the social sector', were also basically neutral, with the outcome of 102 responses, mean value of 2,52 and standard value weighing 0,89.

In the next two questions, the results were very close to those in question 9, with 102 and 103 responses, mean values of 3,17 and 2,39 as well as the standard deviations of 0,93 and 1,18 respectively. These questions were: 'There are no women role-

models in the STEM fields who can serve as mentors to young women in South Africa'; 'Considering the number of young women who are graduates but currently unemployed, South Africa is experiencing an oversupply of jobs in certain fields and an undersupply in the other fields'.

The implication of those questions was that the respondents were not sure if there were role models for young women in the STEM fields in South Africa and also that the high rate of unemployment of young women could be as a result of an oversupply of some skills and an undersupply of others in different fields. That created the impression that young people in general and young women in particular, choose careers without having done any research of what the needs of the market were, to ensure that they get employed beyond their studies.

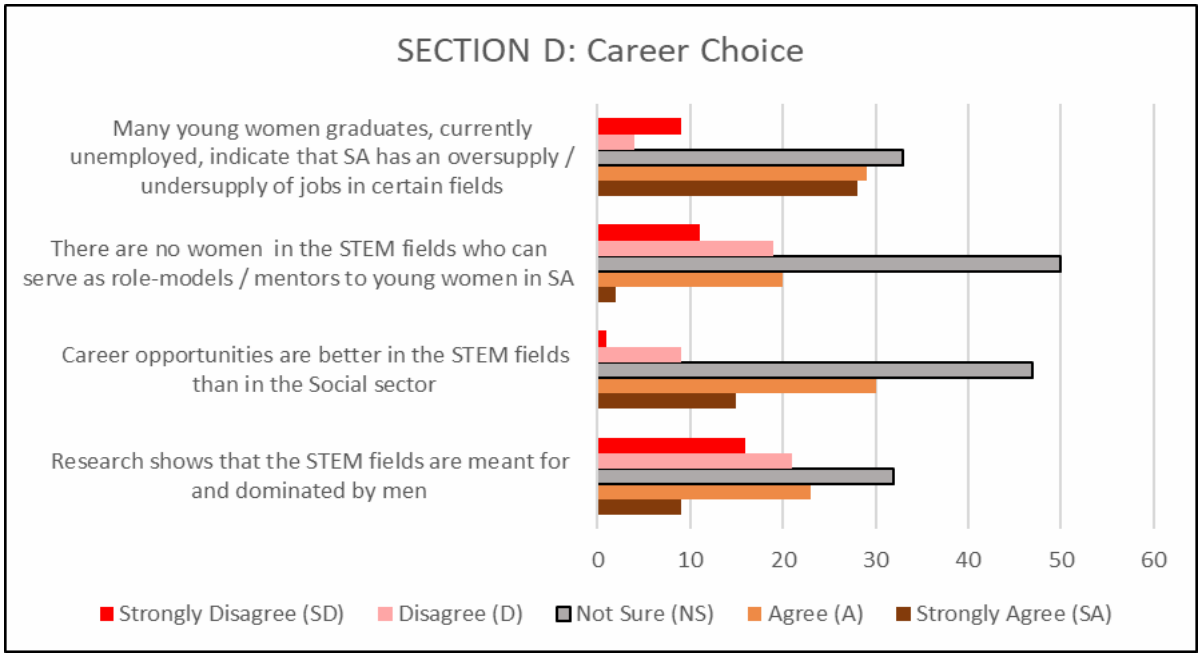


Figure 4: SECTION D: Career Choice

5.3.1.5 University education: Section E

What this section wanted to achieve was to establish whether universities were encouraging and enabling young women to participate in large numbers in the STEM fields where their numbers were significantly lower than those of their male counterparts. There was a need for young women to be made aware through programming and actually be supported, in order to turn around their situation in the

STEM fields at universities where their roll was already high (Department of Women, 2015:43). A higher number of student participants agreed that, indeed universities had a greater role to play in improving the participation of young women in the STEM fields. What they were not sure of, however, was the kind of support that universities could provide for young women to channel their interest and motivation towards taking up the STEM fields as careers, since they were already registering in larger numbers than young men at these institutions. That proved that young women therefore, needed to be assisted in identifying their needs in line with the career choices in the STEM fields.

Table 8: University education

Item no.	Questions	N	Mean	Std. deviation
13.	Your university has a role to play in improving the participation of young women in the STEM fields	**101**	**2,15**	**0,93**
14.	Research shows that the role of young women at universities in general is higher than that of young men and that the number of young women is significantly low in the STEM fields because most of them register to study in the social fields	**102**	**2,62**	**0,91**
15.	Tertiary education is a key factor in a nation‘s effort to develop a highly skilled workforce for competing in the global economy	**103**	**1,93**	**1,01**
16.	The ‘First-time student’ programme of your university informs newcomers of the types of career opportunities offered in all the fields taught at this institution	**103**	**2,32**	**1,24**
17.	The career field in which you are studying now at your university was your first career choice	**97**	**2,51**	**1,39**

Table 8 presents the degree to which universities encourage enrolment across different fields.

These questions are linked to the third objective, ‘To enable young women through programming, to choose careers in the STEM fields in South African universities, as an inspiration for their sustainable/holistic youth development’. The question ‘Your university has a role to play in improving the participation of young women in the STEM fields’ had these results: 101 responses, mean value of 2,15 and standard deviation of 0,93. There, the impression was that there was a general agreement to the question. The results of the next one, ‘Research shows that the roll of young women at universities in general is higher than that of young men and that the number of young women is significantly low in the STEM fields because most of them register to study in the social fields’, were out of 102 responses, with a mean value of 2,62 and a standard deviation of 0,91. The respondents in this case were generally not sure, showing a need for raising awareness regarding the uneven distribution of young women among different career fields, leaving the STEM as the most deserted.

‘Tertiary education is a key factor in a nation‘s effort to develop a highly skilled workforce for competing in the global economy’, was the statement with which the respondents strongly agreed: 103 respondents, with the mean value of 1,93 and standard deviation of 1,01. These results endorsed the sample of this research and also provided a green light to the outcome of this study, i.e. an awareness programme to be implemented through universities. On the next question, ‘The First-time student’ programme of your university informs newcomers of the types of career opportunities offered in all the fields taught at this institution’, an emphasis of the previous one was reflected in the results, also exceeding the average and strongly agreeing that when students set their feet for the first time at universities, they are indeed provided with information on the fields that are offered. The respondents were 103, the mean value 2,32 and standard deviation 1,24. This question suggested that there was a gap in the programmes in which first-year students participate at universities, since they seem not to be appealing to young women to join the STEM fields, where their numbers are small. This response also exposed the value that an awareness programme developed at the end of this study would strongly encourage young women to join the STEM fields.

The last question in the category of university education was: ‘The career field in which you are studying now at your university, was your first career choice’. With 97 students responding, since this was only meant for them, the mean value was 2,51 and the standard deviation 1,39. These results indicated that most of the respondents came prepared to universities to choose the STEM fields as their careers.

This also suggested that very few students changed their minds, even after going through the first-time student programmes that were offered by universities. That said to me as the researcher of this study, that the impact of the programmes meant to inform students of different careers, including those in the STEM fields, was limited. My understanding, deduced from the above question, was that the programmes offered by universities to first-time students were not attractive enough to change the mindset of those young women who have passed the STEM subjects in Grade 12 and did not intend to study in those fields, to change their career choices towards the STEM fields. That was another opportunity presented for intervention as an awareness programme in this study.

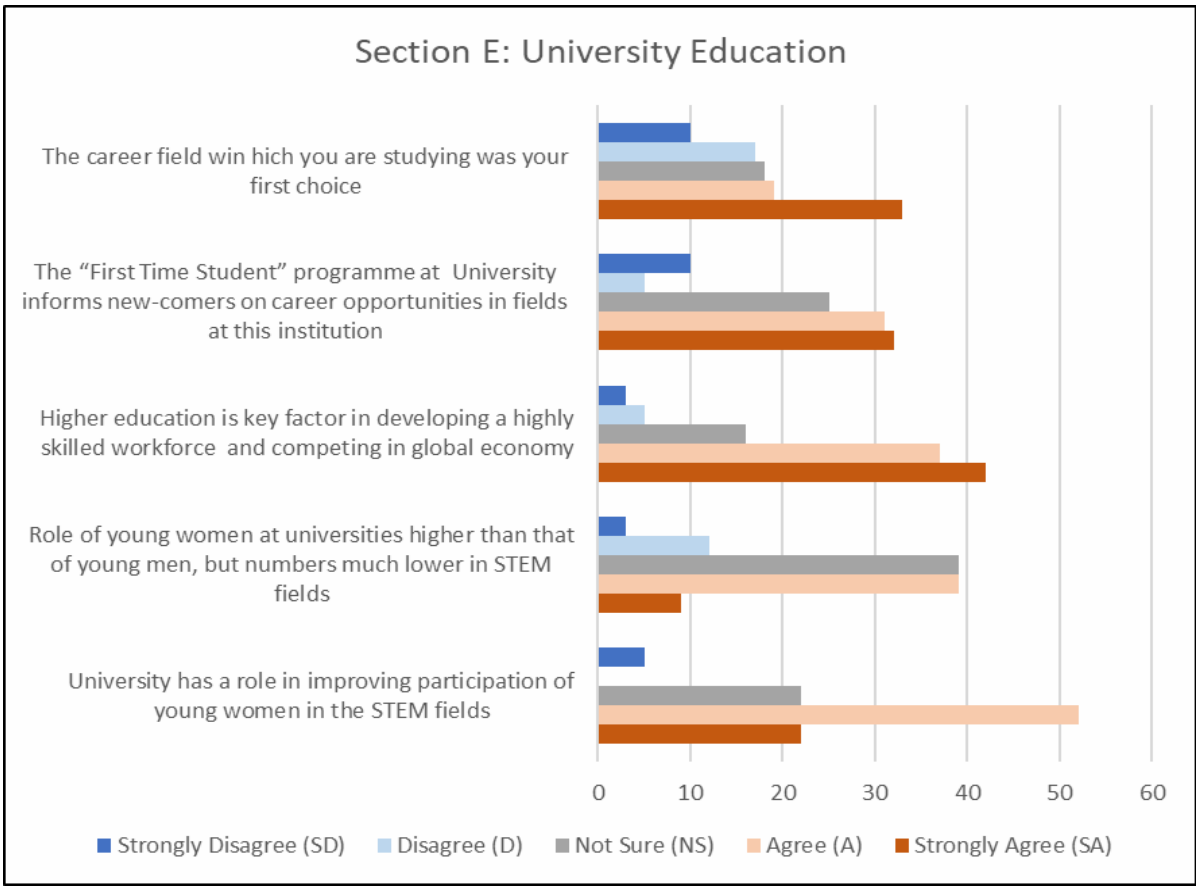


Figure 5: SECTION E: University education

5.3.1.6 Cronbach reliability results

In this study, the reliability results of Cronbach's Alpha are in Table 9.

Table 9: Overall Cronbach results

Number of items in the scale	17
Number of valid cases	80
Number of cases with missing data	23
Missing data deletion	Case-wise

Table 10: Summary statistics for scale

Mean	**43.22**
Standard deviation	**7.47**
Skewed	**1.30**
Minimum	**33.0**
Cronbach's alpha	**.70**
Sum	**3458.0**
Variance	**55.87**
Kurtosis	**3.09**
Maximum	**73.0**
Standardized alpha	**.719**
Average inter-item correlation	**.13**

According to Cronbach's alpha value calculated by the following formula:

$$\alpha = \frac{N \cdot \bar{c}}{\bar{v} + (N-1) \cdot \bar{c}}$$

Where **N** is equal to the number of measurements, **c-bar** is the average inter-item covariance among the measurements and **v-bar** equals the average variance. Obtained from the measurements, there is consistency shown in terms of how narrowly related the measurements are, the value 0.700 obtained from the

measurements, falls in the region of $0.7 \leq \alpha \leq 0.8$, which is the acceptable range not far from the expected reliability coefficient of .70.

5.3.1.7 Developmental programmes: Section F

This category of the questionnaire consisted of questions where participants were given the opportunity to elaborate on, and substantiate, their answers. The responses were clustered according to the main theme, 'Developmental Programmes', part of which was also used to compile the last two questions of this category. The questions in this category were meant to gather information on the respondents' understanding of 'youth development', 'socioeconomic empowerment', 'reasons for young students to choose careers in the STEM fields', 'programmes that are offered by government or universities that are meant to promote the STEM fields', before they could provide their ideas of an ideal programme to improve participation of young women in the STEM fields.

That was taken from the lesson learned by the Korean government who implemented policies and established the Korea Advanced Institute of Supporting Women in Science, Engineering and Technology (WISET), resulting in great improvement and success (Marginson & Tytler, 2015:36). The questions were intended to tease the minds of the respondents to think of other issues that were put as questions in the sub-themes below. The main aim was to highlight the need to embrace all the sub- themes when an awareness programme was developed. As a result, the programme developed and presented in chapter six has taken into account the issues that affect young women that, if addressed, would pave the way for young women to join the STEM fields in large numbers.

5.3.2 Questionnaires: findings

5.3.2.1 Youth development

This sub-heading is aligned to the third goal of this research, mentioned in chapter one, i.e. 'Inspiring for sustainable/holistic youth development for the achievement of an adequately qualified youth community'. The aim of asking for the understanding of youth development from the respondents was to ascertain whether they regard development as important to the youth community for their sustainability. Positive responses would explain it as average, or a need for the improvement of some aspects

of youth development and that would imply that there is a clear understanding of the needs of young people, both male and female, to live life to the full. This would then mean, for this study, that both young men and young women need to be equally developed, in all the aspects mentioned.

An indication was that nearly 80% of the respondents regard youth development as the promotion and assistance for youth to grow up, not only physically, but also understanding the changes that are taking place in their bodies. This includes enabling youth to beat the challenges of adolescence and adulthood and to achieve their full potential as well as ‘making youth better’ with programmes that empower them. The responses included the acquirement of skills and nurturing of talent, as well as empowering youth with a better education system. The suggestion was that youth should be allowed freedom of expression and also be encouraged to chase their dreams, to make positive choices and realise self-actualisation, so that the life experiences of young people are developed in order to prepare them for the outside world.

These responses suggest that youth development is holistic in nature since it embraces the development of all aspects of young people, i.e. physical: ‘changes that take place in their bodies’, emotional: ‘freedom of expression’, psychological: ‘making positive choices’, socioeconomic: ‘development of skills and talent’, etc. Examples of how youth can be developed were provided: through educational bursaries, fair educational chances and opportunity to develop intellectually, in order that youth should be able to ‘discover their strengths’, and experience ‘upliftment in’, including recreational areas’. Some respondents understood youth development to mean empowering youth with entrepreneurship skills, increasing employment opportunities and exposing them to different career choices towards the attainment of economic transformation of the country. One (male) respondent said that youth development means ‘potential in work environment’.

A student (female) provided one phrase for the meaning of youth development as ‘social development’, which illustrates that a developed youth is a socially transformed citizen. This shows the need for the holistic development of youth, part of which constitutes young women, towards social transformation. For others, youth

development relates to knowledge and skills to help communities; enabling youth to be active citizens and to up-skill youth to be able to take important roles within society. This is a confirmation that youth development needs to be sustainable and therefore all aspects of development are necessary to achieve that goal.

5.3.2.2 Socioeconomic empowerment

This sub-theme embraces the second goal of the study, as in chapter one: 'Persuasion for balanced acquirement of skills in the STEM and social fields for young women's socioeconomic empowerment', as a result of the second subsidiary question of this study in the same chapter: 'How can young women improve their participation in the STEM fields, in order to balance between such and social fields for enhancement of their socioeconomic empowerment? There, the respondents were asked to describe what socioeconomic empowerment entails. The aim was to present the relationship between economic empowerment and social transformation with the implication that one feeds the other. Most responses revealed that there is a link between the two and highlighted the importance of being economically empowered. In this research study, this aspect is about joining the fields with scarce and critical skills to the economic market of the country. These fields have employment opportunities and provide market-value salaries or profits (Tjomsland, 2009:412-413) for a professional or an entrepreneur, in order to enable smooth social transformation, i.e. for living economically independent and sustainable lives. Some respondents regarded socioeconomic empowerment as creating and improving the financial stance and economic empowerment of the community, bettering people financially through entrepreneurship and mentoring as well as leading to equal access to finance within society for men and women.

For one lecturer (female), socioeconomic empowerment entails:

- Measures designed to increase the degrees of autonomy and self-determination in the people and communities;
- Enabling people and communities to present their interest in a responsible way, acting on their own authority;
- Empowerment of the nation by government, to improve their state of living economically, through working together.

An element of social responsibility, in the right direction, is also highlighted in the responses mentioned in this paragraph, which is an indication that when individuals are socioeconomically empowered, the whole society benefits. It puts empowerment at the centre of the nation at large, confirming the ACTO (2014) report, that countries (nation) should have the urge to be counted as part of sound future economy (should look for the best talent in the critical and scarce industries). Here are some of these responses: 'Socioeconomic empowerment is the provision of opportunities to previously disadvantaged people with the intention to improve their circumstances'

It is also to give fair chances to people for improvement and 'to put a balance to equalise the past'; Enabling youth to participate in the economic programmes and think more positively; 'Power that one has on the economics of social life'; 'Uplifting youth to be aware of social factors together with economic factors to better the nation'; 'How economic circumstances of the people in South Africa give them power in the society and tackling socioeconomic issues that the country is facing and finding ways to decrease the effects thereof.' One student (female) explained socioeconomic empowerment as, improving the learner's ability to communicate, which is somehow related to, enabling youth freedom of expression mentioned above, under 'Youth Development'.

5.3.2.3 Career choice

What I wanted to address with this sub-theme was, 'To determine the reasons young women do not choose careers in the STEM as much as they do in the social fields'. The purpose was to answer the first subsidiary question of this study, 'What are young women's reasons for not choosing careers in the STEM as compared to social fields in South African universities? Since the sample comprised young female students who had already chosen the STEM fields as careers, the question had to be phrased negatively, in order to get an indication if they had regrets or frustrations, if any, for choosing such fields as careers. The reasons provided were used to deduct and understand why those who choose the social fields in large numbers do not choose the STEM fields. The question was not directed to lecturers and administrators but they were asked what influences the choice of careers of young people, leading to the current status quo, where young women's numbers are significantly lower than those of their male counterparts in the STEM fields. What I had expected was that the

reasons provided by female students would be different from those provided by the male students, since most female students (young women) are seemingly not attracted by the same things that attract young men (e.g. high salaries), irrespective of whether they have good returns or not (Department of Women, 2015:33, 41).

A number of responses depicted the STEM as special subjects, e.g. one (female) student responded that she chose the STEM fields because she was ‘a hard worker’. This answer implied that individuals could only choose a STEM field if they were hard workers, which has an embedded meaning. In my understanding it means that you don’t have to be a hard worker to choose other fields. I also picked up an element of the feminist and classist theories, discussed in chapter 3, and interpreted the above response as stating that, not all women are hard workers, hence they do not choose the STEM fields for careers, therefore, such careers are for men, most of whom are hard workers. Another response was that she liked working with her hands in the laboratory, solving problems. Other participants’ responses showed great passion for the STEM fields, e.g. a female student whose response was, ‘My fields of mathematics and physics made me choose the STEM fields…because I didn’t have another choice, I love it’. Another female student also responded likewise: ‘I felt it was easy to study and I love it’ and a male student said that he chose the field because he knows that he is ‘good at it’.

A male student, who seemed to appreciate his father’s influence, responded as follows to the above question: ‘I grew up with a father who worked in the field, so I grew up learning and getting passionate about these fields’. The other student (also male) said he chose the STEM fields because, ‘I am influenced by people around me and (I also chose them) to lift up my life’. The classist theory is also reflected in the last part of that response, suggesting that, if one would like to live a better life, the STEM fields are the best career choice.

The response from a female student was very direct, creating a suspicion that the respondent was bitter. She said: ‘I did not choose the STEM fields. I was bullied by my parents to study them’. The response in the previous paragraph is an opposite of this one. The male student is happy about his choice of career and the female one sounds bitter about hers. However, the motive from their career choices is the same,

i.e. parents' influence played the important role. They made me think that parents do have influence on the choice of careers towards or away from certain fields. In the case of that male student, who developed the love for the STEM fields because of his father, the influence was positive but a negative influence is reflected in the response from the female student who was bullied into the fields by her own parents. This brought an understanding that an element of cultural stereotyping is still practised by some parents, where they feel obliged to choose careers for their children without necessarily guiding by showing them the benefits of studying the STEM fields, instead of bullying them into such or any other fields for that matter.

This bullying of children and learners in or out of the STEM fields has bitter repercussions as it may even lead to them leaving the STEM fields once they are independent and acting on their own authority. This opinion was later confirmed during an interview with a female student who claimed that teachers (acting on parents' authority) 'automatically' allow entry to a subject to boys when they choose the STEM subjects at high schools, even if they do not have the potential but girls must get their approval to do so. As a result, I carried this issue over to be addressed by the programme developed in this study, and recommended training for the parents of girls and young women who are interested in the STEM fields or the prospects thereof.

The above question also appealed to the respondents to think about the future since studying for a particular career means one is preparing for the future as well as making a difference to others. An emphasis of the need to invest for the future in the STEM fields because of global warming and security of food supply amongst others (ACTO 2014: i) was revealed in these participants' responses: 'I want to contribute to the future of our country' (male student) whilst another said: 'So that I am well updated…the field is interesting because you get to learn about life in general'. The response from a student (male) who is studying to be a STEM teacher was that he would like to empower those who are good at science and technology or those who are interested in the STEM fields as he is. He also emphasised that he is doing this because he likes mathematics. This was supported by another male respondent who said, 'I love maths and science and I'd like to put that same love in other people in order for them to have more career choices when they leave school and another said 'because I know that in South Africa people who are doing maths are few'. In addition

to this, one of them put it simply that he wants to empower the learners whilst a male respondent said, 'I want to better the lives of the youth'. A female student said: 'It's important and I want to make a change' and another female reported that she chose the STEM fields because she wanted to give back to the community.

The opinion of developing young people in the STEM fields in order to pursue a balanced acquirement of skills between these fields and the social fields for their socioeconomic empowerment has been outlined in the responses provided by the students hereunder. The benefit of that as mentioned in chapters one and two of this study (Department of Women, 2015:43), is that neither of the two mentioned fields would be overcrowded nor underused if young women pursue both fields equitably, i.e. registering in large numbers in the STEM fields because their numbers are already overflowing in the social fields (Department of Women, 2015:34). Some responses from the female respondents were that when following STEM fields, one contributes to the development of young people in South Africa. A female student's response was that, she chose the STEM fields 'for stability and to gain a different talent and skill'. In what sounded like a plan for a better future as mentioned above, one female student stated that she chose the STEM 'for better opportunities'.

The previous paragraph also reveals the urge for self-development by young people, which is said to be bringing stability to the future of individuals. Stability is captured as sustainability from chapter one and throughout this study. Hearing it from young people themselves and young women in particular, confirmed the necessity for this study, which also aspired for the socioeconomic sustainability of the young community. This desire continued to be affirmed, as one male respondent said, 'I chose those fields specifically as I know they will develop me in a sense that I will be a critical thinker in terms of finding solutions that are currently affecting our country'. At the same time, there was one who indicated that he liked thinking out of the box and careers in the STEM fields require one to be as creative as possible. 'Thinking out of the box' and being 'creative' form an important part of young people's development.
As previously mentioned, young men are already aware of the importance of technology these days, hence they are already taking up careers in the STEM fields in big numbers (Tjomsland, 2009:411). One of them said he chose the STEM fields because, 'Today the world is about STEM, so it is going to make my life easier to live

and giving me the opportunity to pass on the information that I've learnt to the next generation'. Another said, 'I love information technology, so everything that has technology fascinates me because I want to be able to move with the time always, also to be able to solve problems using current ways of technology'. This found reverberation with one who said he chose the STEM fields because he has passion for science and technology and it allows him to be adventurous. One female student confirmed the traditional stereotypes that, these fields are difficult by saying that 'Back at home many people think that these fields are difficult but for me it has been just challenging and I personally like being challenged'. In addition to these there was one who explained that there were more job opportunities out there and that the STEM fields were his favourite area. One female student said that the STEM subjects helped her to reason out some of the things created and figure a way to resolve them by thinking.

One of the lecturers (male) who was responding to the same question on what the reasons for young people are, to choose careers in the STEM fields nowadays at universities, responded that the STEM fields were challenging and were also an important career choice that was necessary for the development of the country and that without STEM graduates, the country 'cannot develop in STEM areas, power, food, agriculture etc'. A female lecturer responded by stating that there are traditional stereotypes stating that these fields are difficult and not made for women but that is not true.

5.3.2.4 Developmental programmes

The purpose of this question was to ascertain the following: 'How enabling are the current university programmes for young women to choose careers in the STEM fields, for their sustainable/holistic youth development?' in line with the third subsidiary question of this study, in chapter one. That was motivated by Latchanah and Singh ([sa]:52-53) that women-specific development programmes should be introduced 'to provide a safe and supportive environment for women to improve their self-confidence and learn new skills'. The responses would then form part of the third objective, i.e. 'To enable young women, through programming, to choose careers in the STEM fields in South African universities, as an inspiration for their sustainable/holistic youth development'. The question asked about the availability of programmes that were

meant to improve the participation of 'young people' in the STEM fields, not necessarily young women. My aim here was to find out about all programmes related to the STEM fields. If there were women-specific ones as well, the respondents would know and automatically bring them up. This question included government programmes in the questionnaire since government officials who were working closely with universities also participated in this research, although they only participated through the interviews. Because universities are the responsibility of government, especially with respect to financial resources and policies, government had to participate in the research.

The responses to this question were both affirmative and negative as some respondents gave a resounding, 'yes', and others a 'no'. My interpretation for those who responded in a totally negative manner to the availability of programmes, irrespective of whether such programmes were effective or not, was that such programmes were not well advocated. To those who agreed, my understanding was that such programmes were available for young people in general but not sufficiently women-specific to address the issue in question, since women were still registered in small numbers in the STEM fields. One of the male students responded with a definite 'No' in his answer and continued to say: 'The government is failing us'. This means he was aware of the relationship between government and universities, regarding policies and programmes and that government needs to provide guidance, as universities contextualise such and implement (World Bank Report, 2009:2).

Seventy percent (70%) of the student respondents did not know if universities had programmes that enabled the participation of young people in the STEM fields and the rest stated that there were bursaries that promoted the acquirement of scarce skills that were needed in the country since various bursary options existed, such as the National Youth Development Agency's (NYDA) student funding and National Student Financial Aid Scheme (NSFAS). The lecturers were the ones who knew and mentioned different initiatives like the Science and ESKOM Expo Programmes, the FUNZA; Kutlwanong School of Mathematics and Science and the 'First Generation of Students' as well as the 'Grow your Timber' programmes residing in the Department of Higher Education and Training.

The following are suggestions from different respondents that I have edited where necessary and consolidated, as responses to the above question. Some items are the direct words of participants:

- It is necessary to raise funds for technology and assuring women that they will find jobs in the STEM fields.
- There should be emphasis of equity and more opportunities in the country, to bring about stability.
- There should be introductory programmes at schools for STEM and to motivate young women to stay positive.
- 'I was not aware that the participation of young women in the STEM fields is low'; this was the response of one female student.
- Government needs to bring many programmes for women.
- 'A solid maths and science at primary and secondary levels will pave the way to STEM fields at higher levels'; words of a STEM lecturer.
- One young woman's response was, 'safety awareness first'.

For administrators, the last three questions differed from those of lecturers and students respectively, as follows:

- How can young women in your university participate actively in the economy of the country?
- How can your university assist to improve the participation of young women in the STEM fields?
- Does your university have programmes that are specifically meant to promote the STEM fields?

Responses to these three questions were provided by only one administrator, as follows:

- By ensuring that young women study for qualifications in the scarce skills areas, particularly in the STEM fields;
- There is a need for the university to 'increase the admission quota for young women to above 50%. Incentives such as bursaries, work-study opportunities and internships should also be provided to young women (in the STEM fields);
- 'No, currently the university doesn't have such programmes'.

5.3.2.5 Steps to designing a STEM programme

This was the last question of all three questionnaires, for students, lecturers and administrators. Its purpose was to answer the research question in part, by modelling and providing components for the suitable awareness programme to be developed, i.e. 'What are the responsive, awareness programmes that could improve the participation of young women in the STEM fields in South African universities?'. Responses were to assist me to develop, through relevant information, considering the real needs of young women, an awareness programme to improve the participation of young women in the STEM fields in South African universities. The core issue of the study is revealed, i.e. young women. The steps suggested for the development of a programme here were embraced when that programme was designed as described in chapter six.

As a result of the relationship between the above and this question, some of the responses mentioned in the previous question were repeated here by different respondents, e.g. that of provision of bursaries, internships and skills. Some responses were related while others were improved with more information and were mentioned again for greater clarity.

The following is a consolidation of steps provided by the respondents, both lecturers and students:

- An action plan should be developed to 'create a gender-based programme' and the implementers should be confident, brave and active when running it.
- Extra classes for young women to improve their maths and science skills should be part of the programme.
- The promotion and marketing of the programme and the benefits of the STEM fields should be done through Facebook and social media in order to attract women to the programme.
- Continuous research should be conducted and discussions held with young women as they are assessed in the process, through exercises to test young women's ability and to determine reasons why they are not participating in the STEM fields.

- Problems should be identified, the best solutions chosen and implementation be followed by evaluation.
- Women should be given ‘instructions and goals of the programme’, be allowed to come up with plans to form free groups to work with.
- Women should be helped on how to apply correctly in order to be part of the programme.
- There should be trainers for young women.
- Exhibitions of different people in the STEM fields should be organized in order to motivate them.
- Young women should be given equal chances to those of men.
- Up-skill and upgrade young women’s mathematical knowledge from their primary and secondary schooling so that they can confidently embrace their STEM education at a higher level.
- The cost of the programme should be determined and donations and sponsors be sought, e.g. ‘promote women with the BBBEE strategy for businesses that employ people in the STEM fields’ and get information and resources to help them.
- The fight for equal pay should be declared and support groups and relevant stakeholders be brought on board.
- Powerful women in the STEM fields should be invited to talk to the learners and support them.
- ‘Gather women and men who are interested, (to) invest in STEM female development’.
- Redeem the misconceptions; tell young women to focus and study hard and that life is difficult.
- Women need to be involved in the programme, as well as women interns, communicate, accept and work with them so that people can see the impact.
- ‘Young people should not be dictated to by parents’.

One of the university admission administrator’s responses was that there is a need to increase the admission quotas for young women in the STEM fields and provide incentives such as bursaries and work-study opportunities. That was in agreement with Cummings (2015:27), who suggests that gender quotas be used as a policy

instrument that will expedite woman's participation in the STEM, since it will fast-track changes in the gender imbalances in these fields. In addition, periodic workshops should be organised, where young women would be sensitised to the importance of the STEM fields. Field trips to big companies, including those beyond the borders of this country should also be organised. As part of their studies, young women should be put on an internship programme and be placed in big companies.

5.3.3 Document analysis

A comparison was made between the numbers of young women who are registered in the STEM fields against the numbers of those who are registered in the social fields, in particular, the education field. The reported headcount of undergraduate (UG) female students, between the ages of 18 and 35 years in one participating university, within the science, engineering and technology fields was 9 836 in 2015 and 8 440 in 2016. For the education field in the same university, with the same details in the age range of young women the headcount was 41 917 in 2015 and 38 343 in 2016. These were statistics sent by email and said to have been extracted from the HEMIS submission to the Department of Higher Education and Training.

The field of education is only one department within a number of social science fields, from which the above statistics were taken but already this one section of the social science disciplines enjoyed a difference of 32 081 in 2015 (78.0%) and 29 903 in 2016 (76.5%) between itself and three departments within the STEM fields. Although there is an improvement of about 8.5% and 14% between these years, the number in the social sciences is still too high. An intervention in the form of a young women-specific programme was indeed urgently needed, hence this study.

Table 11: Social Science (Education) compared to STEM statistics 2015–2016

STEM fields: STEM & Social Science fields: SS	2015	2016	Difference per area from 2015 to 2016	Percentage change (decrease) from 2015 to 2016	Remarks across years
STEM	9 836	8 440	1 396	14.2%	STEM enrolments went down by 14%
SS	41 917	38 34	3 574	8.5%	SS enrolments went down by 8.5%
Difference between SS and STEM	32 081	29 903			
Difference between SS and STEM as % of SS	76.5%	78.0%			
Difference is higher by 1.5 in 2016					

Confirming the above situation, although the issue of the shortage of young female academics in the STEM fields is not highlighted, the intention of the 'New Generation of Academics Programme' (nGAP) is reported to be recruiting new academics 'against carefully designed and balanced equity considerations and in light of the disciplinary areas of greatest need' (DHET, 2015:17). While this study appreciates the effort brought about by the nGAP to recruit a new generation into the academic world (which I believe to be youth, with young women as priority), what does not come out clearly is the meaning of the phrase 'areas of greatest need' above. Since the main aim of the SSAUF, which nGAP is part of, is to address staffing challenges in terms of size, composition and capacity, I wished to negotiate through the outcome (programme) of

this study, that acknowledgement be made of the fact that the low numbers of young women in the STEM fields should be regarded as a bigger part of the 'areas of greatest need' and be addressed as a matter of urgency.

The Ministerial Statement on the Implementation of the University Capacity Development Programme through Effective Management and Utilisation of the University Capacity Development Grant 2018–2020, reports that the University Capacity Development Grant (UCDG) is being established, among other reasons, to ensure that all developmental needs of universities that had not been attended to and are urgent should be addressed. That forms part of the implementation vehicles for the DHET's comprehensive programme towards transformation at universities (DHET, 2017:3).

It was reported that the UCDP would assist in the development of new programmes and continuously identify 'new disciplinary areas that will contribute to the development of the country'. Moreover, the UCDP would ensure that programmes that had been identified as national and regional priorities were developed and implementation thereof was funded. That would also draw in key stakeholders who would have a contribution towards the success of established programmes (DHET, 2017:15). This study sought to take advantage of the above and its good intentions by highlighting the STEM fields as disciplines that would contribute to the development of the country. Because the UCDP was established to assist the development of any programme that aimed to assist in the implementation of such, the awareness programme, which is the outcome of this study, should be included.

5.3.4 Interviews: findings

There were three types of interviews conducted: (i) government officials (2) from the participating government department; (ii) STEM lecturers (2: 1 from each University); and (iii) STEM female students per university (2: 1 from each university). The number of interviewees decreased compared with the initial target but data collected through this method played an important part in the research. Since I was in contact with the interviewees, I ensured that all information collected would be useful in the research by probing for more information/insight in different questions. In one case, I called the

interviewee to ask for more information because when I was doing an interpretation, I could not make sense of the response.

For interviews, only female students were approached, in order to understand their reasons for choosing the STEM careers, as presented by themselves. This was necessary, for me when conducting interviews, to listen attentively, as well as observing the gestures as the interviewees responded to questions. In the case of lecturers, I was not particular with gender, what was significant was their involvement in the STEM fields. With regard to government officials, they had to be at Senior Management levels and be running programmes that were related to universities. The profiles of all interviewees were therefore, as per the tables below:

Biographical information

Table 12: Gender (students)

Female	02
Total students	02
Total interviewees	**06**

Table 13: Age (students)

20 - 21	02
Total students	02
Total interviewees	**06**

Biographical information

Table 14: Gender (lecturers)

Male	01
Female	01
Total lecturers	02
Total interviewees	**06**

Table 15: Age (lecturers)

28 – 40	02
Total lecturers	02
Total interviewees	**06**

Biographical information

Table 16: Gender (officials)

Male	01
Female	01
Total officials	02
Total interviewees	**06**

Table 17: Age (officials)

35 – 46	02
Total officials	02
Total interviewees	**06**

The interviewees were expected to respond verbally and in detail to each question, in their preferred language. However, all were content to respond in English. The responses by different interviewees to each question are consolidated in the following sections. In the same way as in the questionnaires, the interview questions were classified into themes, which were to gather information through the sub-themes. These were structured as questions. Since both questionnaires and interviews were collecting the same type of information from different participants, the themes and sub-themes were also identical. Interviews were conducted at times that were suitable to the participants, recorded and typed, to ensure that all information shared would be used in the research. Interpretation was later integrated with that of data gathered through questionnaires. The findings presented here were consolidated according to the sub-headings.

5.3.4.1 Youth development

A government official defined holistic youth development as leadership development in universities and working with the department for the development of youth. As explained, education is the basis of all development and later, possibly artisanal training and all other skills development. Since youth comprises persons between the ages of 18 and 35 and universities have a large youth population, development can be done by universities but not only through education and qualifications. It should go beyond that, in addition to the development of psycho-social attributes, to contribute to the country.

That response became very important for this study since it covered three categories of questions at once. It partly identified universities as stakeholders towards the development of youth while they are studying as young people in these institutions. It also answered questions in the category of 'University Education', indirectly suggesting that universities should have programmes on youth development. Lastly, it responded to the last theme, i.e. Developmental Programmes, providing an underlying message that, universities should have programmes that are enabling youth to develop adequately and holistically. In the interest of this study, such programmes should include one that would intentionally enable young women to improve their participation in the STEM fields. If such programme were not in existence, partnership on the implementation of the outcome of this study (an awareness programme) in that regard, should be allowed.

The report on the interviews also indicated that some universities have courses that develop youth in soft skills like ubuntu, which is important. On that basis, it was suggested that such courses need to be structured into qualifications for them to be taken seriously. They should be examinable and assessed, so that youth can have a qualification in them. One participant defined this concept as 'to advance, providing tools for development' while another one said that it depended on context, which may be regarded as the up-skilling and empowering of youth. That meant good opportunities for young people to have skills and programmes that would ensure their sustainability.

As to whether the Constitution of the Republic of South Africa, Act 106 of 1996 promoted youth development enough, there, responses outlined the functions of the Constitution, highlighting that development was not one of those. Instead, policies should do that in different sectors, including government departments. Cummings (2015:8-9) emphasizes that, by advising that programmes and policies that reduce the gender gap have the potential to increase economic growth in developing countries as well as to significantly improve the standards of living of girls and women. One participant said that the Constitution promoted education with the intention of developing people of all ages. The Constitution and Policies were reported to be very good as they cover a wide range of issues, although implementation was always a problem. On the other hand, one interviewee felt that the Constitution did not promote youth development well, especially in the rural areas where most people did not understand it. One participant, a student, said: 'I don't think it does, opportunities are there but I'm not aware (of them), entrepreneurship, sciences do not promote the subject opportunities'. She argued that she went through her junior degree struggling to get a bursary and considered that if the Constitution was promoting the development of youth, she should have known about those opportunities.

What was made clear by the above findings was that the Constitution was not sufficient to promote opportunities for young people in particular. It was the overarching law that needed to be broken down into policies and programmes that were implementable, so it could not do that. Therefore, the above findings advocated for awareness programmes that needed to be developed and implemented to raise awareness of opportunities that were lying out there for young people. That awareness programme had been developed for that and related reasons, as an outcome of this study.

When asked if there was a balance in the development of girls and boys, young women and young men in general, in South African universities, the students were not sure but one official had a different view and explained that it could be true since universities admitted students who qualify, both male and female on merit, according to set standards. So obviously they should be equally developed. He also explained that universities received a lot of funding to support students and that, what they had discovered in government, was that girls were taking opportunities that were meant for women. That, spilled over to them as being more successful than boys. The other

fact was that more girls completed their qualifications than boys and that there was a need for young men to take support programmes that were available as girls do. This explanation confirmed the fact that women were indeed registering in numbers for careers at universities as per Department of Women (2015:43), which was a sign of development unlike in the past. However, it did not specify the disciplines in which youth are proportionally registered and that would reveal the gender disparity in the STEM fields that still needed to be rooted out.

The other participant responded that government should send people and raise awareness in young women, saying:

> We are trying gender equality but have not yet arrived at a true understanding. Some girls are not interested in university mathematics because it is difficult, moving slowly; some things should be made our daily bread.

This participant agreed with Muchie (2015:12) that the STEM subject should be integrated into African transformation, i.e. be compulsory, in order to bring about change in the education system. The response revealed the fact that there was no gender equality in fields like mathematics since girls (young women) were still afraid of them. What was also highlighted was a lack of awareness which should be raised, in relation to such inequality. Of the remaining two participants, one boldly said ‘No’ to the above question, explaining that young people wanted to develop their own brand, as individuals, building credentials that would talk to them. There, my interpretation was that young women needed to be involved in their own development and acquire different skills that would define them as unique. In agreement, the other interviewee explained that, people came from the era where women were excluded from development and that they were still in transition. However, while making efforts to develop girls and young women, boys and young men should not be left behind: ‘Since there is a ministry for women, what about men?’ This explanation for me meant that society should be made aware of the importance of gender equity, in the effort to realise gender equality. This implies that the distribution of resources should not be diverted to young women only but they should be shared equitably, i.e. according to the need of both genders.

To respond to the above concern, the awareness programme developed as an outcome of this study, represents an equitable distribution of resources as there is already a great shortage of young women in the STEM, hence young women have to register in these fields in large numbers in order to balance the gender equilibrium.

5.3.4.2 Economic empowerment and social transformation

From the responses of the interviewees, socioeconomic empowerment entails empowering youth to be active in the economy. Youth may be employed or be initiators of their own businesses but they should have the skills and be trained. At the same time, young people should receive various intervening aspects that ensure social participation, with education and initiatives in communities through government departments like the Department of Social Development. They have to be active citizens as young women and participate in community activities with all other stakeholders. The economic aspect of the concept refers to student support on entrepreneurial skills where economic issues are covered. Some students become business people within universities to support their studies. Socially, there are programmes in some universities for first-year experience of social and psychosocial support, to ensure that they are familiarised with the institution and ultimately pass their courses.

Should the ideas and expectations put forward in the paragraph above come to pass, they would be addressing the first goal in this study, i.e. encouraging an improved number of young women in the STEM careers in South African universities. The participants were aware that in order for the youth community or any other group of people for that matter to reach social transformation, young people should be economically empowered. As stated, young people should be aware of the status of the economy of the country, so that they know the role they need to play. Socioeconomic empowerment therefore means empowering people to contribute and benefit economically and socially, which is what our youth lacked. One interviewee said: ‘Economic freedom in our lifetime doesn’t have to be about black women. It should be about literacy. How about having a black supermarket (the name was removed), taxi industry, people are not empowered equally academically once they don’t have that’. This concept has to do with freedom, to be able to do certain things,

in a certain status and move from lower to middle levels and upwards, to be able to have the basics and meet the needs of all.

Besides responding and relating to the first goal of the study, as indicated, the above suggestions from the interviewees somehow prescribe the remedy for categorisation of people into classes. As per the classist theory, explained in chapter three and its impact on the choice of careers by young women, there are certain jobs that are perceived to be for men and others for women. In the same way, it seems like economic empowerment resides in the hands of those who are 'empowered academically'. The example made by the above participant is that 'black women' need to be equally 'literate', in order to have 'black supermarkets' and be active in the 'taxi industry'. Although the comparison was not complete, in a sense that black women were not compared with any other group. For fear of prejudice, I could not decide on her behalf. Instead, I made my decision and compared black women and black men. Furthermore, for the sake of this study, I had decided to compare young (black) women with young (black) men, that, young women should be 'empowered equally academically' and be equally 'literate' in the STEM fields like their male counterparts, in order to have businesses of their own as mentioned above, and defeat some of the challenges they are faced with.

Young women's basic socioeconomic challenges, related to the lecturers and government officials, were outlined differently by participants. One female interviewee said: 'The social setup and system favours boys more than girls. It is still the men's world.' This agreed with Miles (2000:1), that improving women's participation in reclaiming their share of resources, land, employment and income relative to that of men, was seen as necessary and sufficient to effect a dramatic change in their living conditions.

Emphasizing the above statements, another participant explained:

> Not much has changed; only awareness but stereotyped expectations from girls still prevail. Poverty affects women more and worse than boys.

She continued to explain that there was a need for campaigns of awareness since some girls were missing school because of a lack of sanitary towels. People were never made aware of that in the past, causing lack of access to resources because of

girls' biological orientation. That response raised an element of the sexist theory, which was linked to the feminist theory, in chapter three, that girls need support on the challenge that affects them and not boys, because of their biological makeup. The fact that some girls absent themselves from school when they experience their monthly menstrual period, because of lack of sanitary towels, works as an advantage for boys, if those girls are not supported. Those two theories are also reflected on the information provided as she continued that, some universities complained about pregnancy as 'sex education did not happen in our schools'; 'young women tend to handle things without experience'. At the university age, young women are said to be identifying themselves as women and need to find out for themselves. The challenge, as she emphasized, lied on how they were socialised; girls were not independent at an early age like boys.

When presenting their own challenges, one female student emphasised that women do not know their roles:

> They are still discouraged to be at the top level, since it is only window-dressing. Some young men are appointed to high posts, not because of their potential, but people still think women are not empowered enough.

A lecturer explained that the biggest challenge was that of lack of communication and he suggested that the art of communication should be taught and be part of the curriculum. He said: 'Women need to learn to articulate their views in a way that will allow them to be heard'; 'Being polite in saying what they want'. Once again, the issue of how women claim their space was revealed in these findings, since research had proven that young men have the tendency to over-report when explaining their past performances (Reubena *et al*., 2014:1403). A female student emphasized on that, by stating that socially, being able to get a high position was difficult and in science there was a misconception that it was male-dominated. She continued that young women needed to be economically stable, which meant having your own house, car, amongst other things. She confessed:

> The social beliefs curb the movement, for me, I don't have a car, can't travel freely, I have to stop that; I need money for myself but have to assist at home, a single parent's home.

The culturalist theory emerged in the paragraph above, where the participant expressed the feelings that she was deterred from economic independence since she had to assist with her single mother's household needs, instead of catering for hers. My interpretation of the word 'have' was that she believed that she had cultural obligations that she had to fulfil, over her needs. That, was also evident, as presented previously, under questionnaires findings, where a female student responded that she didn't choose the STEM fields as a career but was 'bullied by her parents.

The next question asked was to ascertain whether young women were aware of the scarce and critical skills to improve the economy of South Africa. For me, the negative responses would confirm that the choice of careers by young women was done out of ignorance of the economy and the market. The positive responses, on the other hand, would suggest that if young women were aware of the economic situation around them and still choose careers that were not guaranteed good salaries and more work opportunities, then the reasons for choosing careers away from the STEM fields would be something which was more influential, like culture and tradition. The participants had different views on this question; some thought all skills were necessary, with which I agree, but they missed the fact that some skills were oversupplied, which saturated the market at that point and lead to unemployment. There was an over-abundance of what was needed, while on the other hand essential skills were undersupplied and that part of the market remained unfilled. The following paragraphs contain answers to this question.

> There are a lot of such skills that are needed by the country. There is a list at Home Affairs that has such skills because outside people, i.e. foreigners are applying to come to this country and do such jobs. Another list should be found at the Department of Labour (the female official's response).

One lecturer (male) said: 'The STEM fields are critical, medical fields are still short of practitioners who are the products of such fields'. When answering the same question, a female lecturer said: 'STEM fields… Here the college is big but there are only two ladies. All must participate; we are all equal in potential'. The other interviewee thought financial literacy was very critical and not really the sciences. However, priority was important, given a list of all critical skills, i.e. economics, agricultural science,

communication skills and political literacy. From this finding, that would assist in curbing the issue of many graduates that were without jobs. Problem-solving skills were important but not generally studied, for example science. This discussion touched on what the second goal of the study was, i.e. ‘Persuasion for balanced acquirement of skills in the STEM and social fields for young women’s socioeconomic empowerment’, leading to the development of an awareness programme as the product of this research.

The findings on how young women at universities could participate actively in the economy of the country were very similar. In general, the interviewees believed that it was hard to expect students to participate except for engaging in education, although it drained the education sector because of subsidies and bursaries. Students who could still generate revenue while studying were a bonus to the system. Education should be for the sake of education and not just for employment. It should not be used to channel people for jobs. All sectors were important, e.g. teaching. Teachers were still in short supply but those of certain fields like the STEM were needed more than others. Those responses emphasized the need for young women to engage in, not only education, as their contribution to the economy of the country, but in the STEM fields in particular, where they are most needed.

‘There is a need for in-service training in areas that are not well-populated’. A government official said:

> Basic education system is good in ... (country), it looks like the system is giving students a good foundation, i.e. the whole schooling system, including curriculum, areas of focus and the delivery of curriculum etc.

The other interviewee (a female) said that studying hard, succeeding and quickly finishing their studies in order to work and contribute to the community, was the contribution that young people could make to the economy of this country. There was a need to research for innovation. Young women should be involved in research whilst at universities and not just in methodology but also participate in practical research. They need to understand the theory and be able to be practical about it. Young women already have to show entrepreneurial skills. The pillars for universities are: teaching, research and community service. They should address all of them and participate in

the community services more. There is a need for programmes to enable them to participate, roles defined and awareness of programmes should be introduced. They need to take part in the development of such, know how to benefit and how much they will contribute. They also have to indicate their interest and need a platform to do that, in order to stay motivated.

One interviewee answered with emotion to the manner in which young women should contribute to the economy of the country. The respondent said that some youth think they learn skills only to become employees but the era allowed them to be entrepreneurs, saying emphatically: ‘Stop studying to write a CV; start learning how to do business plans’. By actively participating in the economy, young women need to learn certain skills. They need to consult with economists to explain how to do it. These days learners are taught to think but in the past people were taught ‘how to be in the classroom’, which taught them to be independent in their profession. That means curriculum needs to be amended.

The following question was also referring to government officials and lecturers, on what the requirements for social transformation were, that government and universities could contribute towards young women’s achievement in the STEM.

It was explained that all aspects of the lives of people in South Africa needed to be transformed because of the apartheid background. There was a need for the re-engineering of lives, especially for previously disadvantaged people. In this case, programmes that were intended for young women needed to be developed. Young women should be the first to benefit, as in the ‘New Generation of Academics’ programme. It was meant for young female students from previously disadvantaged backgrounds and they benefitted a lot (DHET, 2015:6).

One lecturer advised that all lecturers be involved with community projects in different faculties. They also needed to share the research findings with teachers in schools. There was already a project running, on tutoring in schools locally. However, lecturers also needed to ‘decolonize’ the curriculum since students were diverse and that had to be embraced. Teachers should also plan lessons together. A change in the curriculum and the way it was delivered was necessary. As he continued, he asked a

question, ‘Why can’t rich people be the ones teaching the learners and students on how to make money?’ He advised that such issues were better taught by people who had been there and that would motivate students to learn even more. A student interviewee added to that idea, when stating that school is the first start but not the only destination. The education system ‘should allow for the bill gate’. People should be made aware that not only education can give you good life. Some students struggle at school. There should be opportunities for such people.

5.3.4.3 Career choice

For this theme, I believed that the influence behind young people’s choice of careers was important to establish and it would expose the cause of disparity in the STEM fields, since young women are part of that community. The interviews with female students themselves shed light on the element of caring and upbringing as mentioned by Ledwith and Manfredi (2000:20). One female student answered that she chose to be a STEM subject teacher because she wanted to strengthen the knowledge of such fields to children at primary and secondary schools: ‘If we need higher participation in STEM fields, we have to develop interest and training at lower levels’. The other participant (a male lecturer) explained that there was always availability of jobs in the STEM fields. That was in agreement with Besecke and Reilly (2006:4–6) who also contended that the field of STEM needed more talent and, in particular, young women’s talent. This participant added to his earlier statement that, there was however, a need for young women to join the STEM since ‘academics in those fields were mainly old male whites who were occupying the jobs but should accommodate young black women’. That was also confirmed by the DHET (2015:78).

When answering this question on what was the influence behind young people’s choice of careers, one student blamed the way boys and girls were socialised, that led to few young women in the STEM and a high number of boys choosing them as careers. She, however, also mentioned the fact that blockages were starting to be unblocked. She said,

> Indoctrination was there in the past that STEM subjects were not meant for girls. Maths and science were normally taken by boys without questions from teachers, unlike if they were taken by girls.

There is an element of discrimination in the above response as girls right from the beginning seem to be ostracised by some teachers who still believe that the STEM are subjects meant for boys alone (Reubena *et al*., 2014:1403).

In the following paragraph, the interviewees explained how costly the STEM fields were to study: 'the STEM fields require a lot of money to study'. The findings of the study by Auston and MacPhail (2011:53) showed that young women were choosing careers taking into consideration the costs of the institution where such careers were offered. In most cases, colleges won as institutions of choice since their costs were less than those of universities. Even on the issue of distance between their homes and the institution of higher learning, young women would choose the closest institution to their homes, not necessarily the one that offered their first-choice of a career. This participant continued to say, 'Other students had passion but because of the financial pressures at home, they did not want to disappoint the parents, even though they were aware of the significance of the STEM fields'.

A student (female) interviewee explained that she loved science and wanted to become a doctor. However, she finally chose to be a science teacher because the costs of medical studies were too high. However, since she loves the STEM fields, for her, a teaching career is 'more spiritual than anything'. She explained that a lot of learners find it difficult to relate to people at higher levels and it takes an effort for someone to relate: 'I love the whole idea, putting myself to the learners in order to help them to take the sciences.' An opinion was also raised that young women who want the STEM jobs need to think of the three generations to come, to educate their children about these subjects, since a lot still needs to be done. Once again, the culturist and classist theories erupt. Young women seem to be considering their parents' needs over theirs as well as choose careers based on what they can afford to pay and not according to their potential and interest. Young people seem to be needing support in terms of sustainable funding for their career choices. This also contributes a lot towards the outcome of this study, i.e. an awareness programme.

On the question about the stereotyped talks that the STEM fields are for boys and not for girls, it was suggested that girls were raised and told that the STEM fields are for men. The experiences of different participants in their workplaces, in this case, at the

participating universities, showed that there were indeed many stereotypes since enrolments of young women in the STEM in higher education system were low, especially at postgraduate levels. One participant argued that she would not call it a stereotype; instead, there is a need for a better analysis of why the situation is like that. She continued to explain that some of the reasons for low enrolment could probably be the kind of exposure at lower levels. We tend to react differently for boys and girls, e.g. girls are more exposed to cooking and boys to cars, etc. A scientific view of the whole concept of exposure would be more beneficial, e.g. exposing girls to cooking, from farming where food is planted to where the food is processed and ultimately cooked. Girls should be exposed to the 'science of food throughout the value chain', as boys are exposed to driving and cars, which results in knowledge of the 'science of cars', not only the opportunity to drive them. In addition, medicine should start at plants that are used to make medicine and not just the idea of being a doctor. This view is also shared by Erwin and Maurutto (1998:53), in that the predominant focus in the literature has identified differences in innate ability and early socialisation practices to explain why girls tend to avoid science in primary and secondary schooling, which happens in both developing and developed countries.

The above ideas of exposing girls to scientific processes around them, from the elementary level upwards, became very important for this study. That also raised an idea of mentorship of different levels of education on the STEM fields. One interviewee reported that statistics showed that elderly white males mainly dominated the STEM fields and that, each STEM young female lecturer must have such people as mentors, although that was not easy to arrange. However, the mentors in the STEM fields, who were usually elderly white male members of staff, needed to be trained on how to mentor these young women (Baltodano *et al*., 2012:67; Hazari *et al*., 2017:15, 18).

A female lecturer reported that young men and young women perform the same tasks and at the same levels in the STEM fields. The male one differed slightly but confirming how young women were at a greater advantage that boys although they participated in lower numbers. He said 'Having worked in four universities so far (I can safely say) women do better (in the STEM). Men have lost their agenda.' A female student participant's answer however, showed a disadvantage of being a woman in the STEM fields, that, according to the history of this country, by hierarchy, women find it hard to

get high positions, irrespective of their good performance. There is a need for a paradigm shift, which is fortunately taking place although very slow. The more programmes developed, the faster youth would be enabled to have experience of the STEM fields even before they start work.

The purpose of the question on the comparison of the STEM and social sectors with regard to the better career opportunities offered was to check if the participants, young women in particular, understand the difference between the two sectors and which one needs to be promoted more for young women. A government official responded in this way:

> One can't compare the two. Choices as well depend on the tastes of different people and interests. It should be exposure for every field; social scientists are also as necessary as STEM fields. They are just not well exposed. Hard-core sciences are as good as the social ones.

I thought the response was fair but did not address the concern of the few social sciences that were then overpopulated, i.e. health, welfare and education (Department of Women, 2015:43). However, that would need a different study. For this research, young women were encouraged to take up careers that would place them on the same levels as their male counterparts, who were already benefiting through job availability, high salaries and so on (Tjomsland, 2009:412–13).

For other interviewees the STEM fields did have opportunities in line with other fields but an emphasis was made that this should not be the case and needed to be corrected. Of all the STEM disciplines, the most popular were engineering and technology, which young women were encouraged to join in large numbers. One participant (lecturer) reported that the development of mathematics and statistics programmes is managed by the DHET. Remuneration in such careers was higher if individuals worked in the corporate world than if they were lecturers. However, government as the main employer in the country should establish departments, specializing in engineering and other STEM fields. This interviewee also commended the conduction of this study and said 'Since there is a shortage of young women, this research is important for that'.

This paragraph addresses the issue of the mentorship of young women in the STEM fields. It is said that this concept has borne good results in the countries that implemented it (O'Dea & Corcoran, 2014: i). However, I thought it would be ideal if mentors for young women could be women who are already employed and have businesses in the STEM fields in South Africa, so that young women should have experience through them and realize that these fields are not meant for men only but also for women. The question here was to ask participants to make recommendations on what female role-models should bring as an expectation, when mentoring young women in the same fields at universities.

In response recommendations were provided but with caution from the implementers, as one female student said: 'Role models are a narrow area. People are assumed to be the ideal ones whereas the impact may not be what is expected'. My interpretation of this was that some role-models do not necessarily do what is expected of them for the mentees and the process tends to achieve only negative instead of positive results.

Because of situations as the one above, training for mentors was recommended to curb the achievement of unexpected results. It was also recommended that training be provided to as many teachers and people in the STEM as possible, to create a wide interest that would spread across the country. This should be done at all levels, even at the early childhood development (ECD) level. Creating interest should also mean making it easy for the mentors to be accessible to the mentees at all times. Training for the teachers should also include mediating the subjects and making them interesting and simple for the learners and students. On the other hand, an interviewee who seemed pessimistic about the idea of mentors in the STEM fields said:

> There would be clashes because of the age difference of the current STEM mentors for young female STEM lecturers at universities and also because most of these mentors were operating during the apartheid era, so it is difficult for them to transform.

Recommendations were also added to the concern of this participant that formal structures should be established and intentional programmes be put in place for such mentors. It was requested that the DHET should be the body gathering the mentors and encouraging them to share their experiences, in formal and informal meetings.

A female student suggested that, the kind of mentors to be identified ‘should not just appear on TV’ but should go to various places, have contact sessions and be accessible to their mentees. They should not merely give tips to the mentees but adopt them and meet them at least once a month. That would assist in changing their attitudes, sharing experiences, touching their lives and motivating them by having personal sessions with them. Mentors should also be visible and communicate through social media. Another female student, who could not find a mentor in her undergraduate studies and consequently wished to be one, said:

> I love this question. When I was completing the degree, I had been looking for a mentor since 2014, which I only found in 2016. Most are men. So far, I only know of one woman-mentor. I aspire to that. They (mentors) need to close the gaps between the students and them. She (woman mentor) made a decision to become a role-model and be accessible. They have to reach out so that other students can be aware of them and communicate with them.

In view of the above information, the developed awareness programme in this study has embraced the issue of mentorship for young women in the STEM fields, as part of its processes.

As part of the above theme, participants were asked if South Africa was experiencing an oversupply of skills in certain fields and an undersupply in other fields, considering the number of young women who were graduates but unemployed then and to provide reasons for their answers. The answer from one interviewee was an outright ‘Yes!’ The ‘conflicted’ situation in South Africa was said to be interesting in that the labour market needed employees but at the same time graduates were unemployed and needed jobs. In that case recommendation for retraining and channelling people to certain jobs was done. South Africa was advised to take lessons from developed countries and do things properly. That recommendation also became important for this study, not only as a modification measure, but as part of the planning, to avoid the above situation, i.e. the market needing employees and yet graduates staying without jobs.

One participant referred to the question as controversial. She reported that about five years ago there was an oversupply of teachers but later on there was a shortage of young women in the STEM fields. She suggested that the link between the curriculum at universities and the need out there should be strengthened, e.g. 'engineers from universities need the support of artisans but currently there is a disjuncture'. Therefore, the need for re-skilling and amending the curriculum would assist since there was too much theory above practical work, e.g. training of doctors is different because of resources and machinery. The respondent said:

> Should a doctor who was trained at one of the well-resourced universities, like the University of … (name of a well-resourced and developed university was withdrawn), go to work in the rural areas, this person would always see the need for machinery rather than finding other ways to cure patients, in comparison with a doctor who had trained at a rural university

The issue of re-skilling came back again in another participant's answer:

> The situation is not really as the question presents it; there are certain skills that need to be learned in the STEM fields. There is however, a need for new programmes that are focussing on maths. Student teachers need to go through such in order to be able to work at TVET colleges. Lecturers should raise awareness in students of such programmes, e.g. some lecturers went to China to learn more of technology and have to implement this in South Africa. Programmes of such nature need to be developed for young women.

This respondent quoted the previous President of South Africa, President Thabo Mbeki, saying that universities needed to teach skills that were relevant and that young people needed to know that 'besides the degree, they have to be go-getters'. In agreement, a student participant complained about the conflict of interest that was displayed in the country, where you read an advertisement in the newspaper but when people apply, they do not make an appointment because more often than not young candidates do not have experience or they are said to be overqualified for the advertised post, which she thought was an example of a 'life-long learning' that government was encouraging all to do. The corporate world was said to be better than government for the graduate internship programmes, which some departments did not have and needed to correct. For this study, this recommendation was used to propose

that government should forge collaborations with the private sector for the implementation of the graduate programme of young women in the STEM fields.

5.3.4.4 University education

Government officials were asked specific questions on how the government could assist universities to improve the participation of young women in the STEM fields. The answers were that government should intentionally put in place programmes and bursaries that were for young women in the STEM fields. Universities were also advised not to work in isolation to enable access since collaboration on how to approach other subjects like mathematics may be learnt from other stakeholders. Universities were also encouraged to have incentives like government, in addition to the fine work these institutions are doing, where workshops are held for masters' and doctoral students where academics were developed.

Different researchers had noted that in general the role of young women at universities was more prominent than that of young men and that the number of young women was significantly lower in the STEM fields than in the social fields at universities (Department of Women, 2015:34). The interviewees were asked to provide reasons for that situation. One of them said:

> Socialisation as we grow up has a great impact in that girls have more challenges of becoming independent than boys and women are afraid of the unknown since they were not as independent as boys when they were growing up.

Answers from some of the participants were (male lecturer):

> Young women want to study fields that will not give them problems; they do not want to do practical work. On the other hand, the level of poverty is high and they are running away from it, hence they want to finish school quickly. They need to be made aware of such.

A female student said:

> Most young women register in communications, law and the humanities because they fear science since they think it is difficult and also takes long to master. They need to be made aware that there is always something new and they need to keep ahead.

One of the questions was to check whether government had a monitoring tool to determine the standard and principles for the ‘First-time student’ programmes of universities, in order to ensure that newcomers were well informed of the types of career study opportunities offered, without taking away the autonomy of such institutions. This idea was also recommended by Elster (2014:58), that, the provision of support to first-year students, by advising them of how important, interesting and meaningful STEM education is to their future lives, is necessary, in order to prevent dropouts. A male interviewee responded with a ‘No’, to the question, explaining that the Constitution guaranteed academic freedom to universities. He explained that government did not have the right to have influence on what to offer, unless it was based on universities’ plans. In that case, trust should be put on academics’ ability to deliver the right curriculum and how to teach. However, the promotion of learning was important and government ensured that the environment was good for universities to do their work. On the contrary, another one said ‘Yes’ and also explained that there was a ‘Career Guidance Unit (KETA)’ in the DHET that worked with universities and high schools to help. The unit had a Twitter and Facebook account, for careers and registration. Funding through first year experiences and other warning systems always indicated whether students needed support within the universities. The DHET was funding those programmes, although such were not compulsory. Progress programmes were also implemented, to check if the students were making progress or needed help to do so. On the part of the universities, there were academic advisors who encouraged and advised the first-year students. They informed as well as assessed students for courses they intended to take and offered them good advice.

My concern about the two conflicting responses was that they came from officials who both worked in the same situation and at the same level. That made me to think of different stakeholders that my awareness programme needed partnership with and how that could be well resourced, and most importantly, well advocated for. Measures and principles on how best to implement that were therefore developed, and are outlined in chapter 6, in order to avoid the above situation whereby the intended beneficiaries were not aware of that and related support-giving programmes.

For students there was a question on why they chose to study at a university and not at any other HEI and what their expectations were from it. The aim here was to check if young women started choosing institutions first the basis of its location and costs than on the list of careers that were offered, as suggested in the research conducted by Auston and MacPhail (2011:53). The response from one was:

> I always wanted to study medicine but I had (financial) challenges. However, I still chose to study at university because university has a different life full of fun.

Another interviewee said that her parents believed in a degree that was globally accredited, not necessarily a university. However, she wanted to be sure since universities were ideal. That, in a way, confirmed that this study was conducted in the right space (universities) and era, for its purpose.

5.3.4.5 Developmental programmes

In this category, the interviewees were asked whether they were aware of programmes at their institutions that were intended for the improvement of young women in the STEM fields. The question was important for this study since I wanted to avoid duplication. In the case where such a programme might be available, I would then opt to collaborate in strengthening it. The fact that the number of young women in the STEM fields in South African universities is still significantly low showed that if there were such programmes it would mean that they were not well publicised. However, the answers were basically in the negative. What came out clearly from the government's side was that it had ensured that the environment of teaching and learning at universities was good and it also provided funding in the form of subsidies and bursaries to enable universities to do their work.

A government official also reported that there were new developments, like a programme called 'New Generation of Academics', which had a section within the DHET. "This section provided, through this programme, capacity development based on the need of different universities. On the other hand, universities needed to make the DHET aware of the challenges and requests for help, especially in the historically disadvantaged institutions", she explained. In support of that, one lecturer reported in a different interview, that there were discussions between the two sectors, i.e.

government and universities on the lower number of women who were working in the STEM fields and that, information was being compiled in that regard. The student participant agreed that there was a lot of information provided during orientation but since there was already a concept that the STEM fields were difficult, especially at university level, most students (young women) avoided them.

In this category as well, as per the above response, the negative sex-based stereotypes that the STEM subjects were difficult have emerged, indicating that little could be done to influence the choice of young women who are first year students to take up careers in the STEM since they came from their homes 'knowing' that the STEM subjects were extremely difficult at university level. This 'prejudice or discriminatory attitudes…', as defined by Shin and Lee (2017:4), indeed promoted the unfortunate stereotypes that disadvantaged those young women, even before they start with their developmental journey at universities. That also responded to the third sub-question of this study, 'How enabling are the current university programmes for young women to choose careers in the STEM fields for their sustainable/holistic youth development?' The third objective that provided the reason for that question, was 'To enable young women through programming, to choose careers in the STEM fields in South African universities, as an inspiration for their sustainable/holistic youth development', as well as ensuring the realisation of the third goal of this study, i.e. 'Inspiring for sustainable/holistic youth development for the achievement of an adequately qualified youth community'.

The intention there, was to find out where blockages could be and contribute, though this study, to unblock those, in order that young women could improve their participation in the STEM fields like their male counterparts. The statement from the above paragraph, 'The student participant agreed that there was a lot of information provided during orientation but since there was already a concept that the STEM fields were difficult, especially at university level, most students (young women) avoided them', assisted this study to understand that the challenge does not start at university level, even though the study would like to make an impact at that stage. As a result, the awareness programme that was developed as a result of this study, embraced the challenges that might be the root-cause of the low numbers of young women in the STEM fields at university level. The programme therefore, included some activities

that improve the participation of girls from the lower levels of schooling, before they become young women, who are in the position of choosing careers at university levels.

5.3.4.6 Steps to designing a STEM programme

In getting a sense of how interviewees would go about designing a programme to improve participation of young women in the STEM fields at universities, should they be requested to do so, the following were their responses. A government official said:

> The first thing would be to develop teaching and the teachers of different levels in the STEM fields, in every school. Creating interest for learners is also important. The programme will have to be intentional, to address the challenges and requirements for women at the age of university attendance that is 18–35. Focus on those in the rural areas also needs to be catered for through setting percentages.

She continued to explain that a programme on designing lessons would be necessary, before such a programme could be started. The need to work with people who have passion for the empowerment of women in STEM fields would be a priority, also ensuring the participation of other, relevant stakeholders and hosting a symposium to create awareness. One lecturer emphasized the need for learners and students to be consulted, to identify their needs and then build a programme based on that, in high schools as well. They would then own it and implement it smoothly and then there would be a need for a monitoring tool to be developed, piloting the programme in certain institutions first and then getting information from the pilot project to improve it if necessary. Recommendations and amendments should be implemented and young women who are interested in the STEM fields encouraged to participate. A database could be established of young women who are interested in the sciences. Even those who are unemployed would be supported with bursaries. In their final year, students should be given information on programmes beyond the undergraduate levels. All the above proposals were considered and some were used to develop the awareness programme at the end of this study.

5.4 SUMMARY

The findings in this chapter spring from the analysis of questionnaires, documents and interviews which directed the advancement of recommendations leading to the

outcome of this study, the sequel of that, which took the form of an awareness programme outlined in chapter six. Those findings revealed a gap that displayed the reality of the significantly low number of young women in the STEM and the various scenarios that have led to that situation. The findings also presented the opportunities that could be explored in order to close such a gender gap within those fields, laying a solid foundation for the developed awareness programme that was intended to remedy the situation at hand.

CHAPTER SIX

RECOMMENDATIONS

6.1 INTRODUCTION

This chapter consists of recommendations in the form of a programme, as a result of the research analysis in this study: 'An Awareness Programme to Improve Participation of Young Women in the Science, Technology, Engineering and Mathematics (STEM) Fields in South African Universities'. It outlines steps that may be taken to improve the participation of young women in the STEM fields in South African universities. Some of these were implemented in other countries but had to be contextualised to fit into the situation of this country with ease, in terms of the higher education arena and the STEM field.

My perspective is that, if the STEM fields are regarded as the main contributor to the alleviation of food shortage and other related results of global warming; these fields offer well paid, market related salaried and high-status jobs; women are under-represented in the STEM fields; South Africa needs a balance of skills choice between Social Sciences and STEM fields in order to compete in the global economic market, etc., then these fields should be prioritised. Since this study has also proven that there is a shortage of young women's talent in such fields in South African universities, programmes that are meant to close that gap should be developed and implemented as a matter of urgency. Therefore, based on the aim of this study and guided by the findings, in addition to the lessons learnt through literature review, I found it suitable to develop the following programme.

6.2 THE PROGRAMME

6.2.1 Programme title

The title of the programme is **"i-STEM".** The article 'i', represents the key action word of this programme, i.e. 'improve' and the word 'STEM', is an acronym of the concepts, 'Science, Technology, Engineering and Mathematics', which are the targeted fields and main focus of this study. The **'i-STEM'** is **'An Awareness Programme to Improve Participation of Young Women in the Science, Technology, Engineering and Mathematics (STEM) Fields in South African Universities'**.

6.2.2 Purpose of the programme

The purpose of this programme is to create awareness to communities in all sectors, education, academia, youth, women, government, civil society, religions, etc. and to young women in particular, that young women's numbers are significantly low in the STEM as compared to the social fields in South African universities. The ultimate aim is therefore to enable young women to improve their participation in the STEM fields in South African universities, in order that this sector can have more women professionals, who are currently the missing talent.

6.2.3 Background to the i-STEM

The shortage of young women's talent in the STEM fields causes imbalance of the skills distribution scale, resulting in gender disparity in that sector. Young women have been found to be learning skills that are oversupplied for careers instead. The impact of that is felt in the high unemployment rate of young female graduates. Fortunately, there is a chance for young women to acknowledge their shortfall, reverse the situation and get on the right track towards a holistic youth development and live sustainable lives. Young women can be assisted through programmes such as this one, to deal with the issues that influence them to choose careers away from the STEM fields that are said to be socioeconomic vehicles and turn their choices around towards economic empowerment and social transformation.

The National Planning Committee (NPC, 2011:27), through the National Development Plan (NDP) 2030, encourages all South African citizens to take charge of their own development in a variety of ways. This committee draws from the historical background of the country that, through activism liberated itself from the apartheid regime and is still using its voice to ensure the protection of its rights. The citizenry is inspired to initiate and be the direct participants in their own development since it has never been the government's intention to play a bigger role but rather to actively support and incentivise citizens in their efforts to advance. The incentives are meant to stimulate the South African citizens to actively learn and advance towards opportunities that will bring about social transformation (NPC, 2011:27).

In line with the NDP 2030, the i-STEM programme is one such initiative, advancing the development of young women by young women themselves, supported by the various stakeholders mentioned in this chapter, including the government of South Africa.

6.2.4 Stakeholders and roles

In order for the programme to be smoothly implemented, there is a need for a wide range of partnerships between people who are affected. Roles will have to be outlined in order to avoid duplication or redundancy from other sectors. There will also be areas where the roles of two or more stakeholders are intertwined and collaboration in such cases will be the key to success.

6.2.4.1 Young women

Young women are the main stakeholders of the i-STEM programme because the issues and plans here are about them. As a point of departure, they need to be aware of their situation regarding the STEM fields, i.e. their numbers are very low in such fields in South African universities (Department of Women, 2015:43). On the other hand, young men are already participating in large numbers in the STEM, the fields that are said to be paying high salaries and that offer high-level jobs (Tjomsland, 2009:411). However, young women are reported to be registering at universities more than young men but in the education, health and welfare sectors (Department of Women, 2015:43). These skills are oversupplied unlike the STEM, which are undersupplied with young women's talent. In order for young women to remedy this situation, they should increase their registration in the STEM rather than the social science fields. This programme therefore proposes strategies that will assist them in this regard.

6.2.4.2 South African universities

In line with the National Development Plan (National Planning Commission, 2011:8), one of the attributes that South Africa would be expected to have is that the higher education sector, of which universities are part, should have been expanded to the extent that it could contribute to 'rising incomes, higher productivity and the shift to a more knowledge-intensive economy'.

Universities would be expected to have partnerships with the science councils and different institutions of research, in an effort to initiate and develop priority areas of the country's economy. South African universities therefore are expected to prioritise skills that are critical to the economy by developing and/or implementing at least one programme which is intended to improve and enable young women's participation in the STEM disciplines, aligned with the principles and regulations of the specific HEI to which they have applied. Universities could recruit 60% of young women for every STEM discipline offered, by intentionally assisting young women with bursaries from undergraduate to postgraduate level. Registered young women should be allocated female lecturer guardians, or mentors, who would monitor their progress throughout their studies. The staff-student ratio would be determined by the overall number of young women registered per year. Both lecturers and students, i.e. young women, would be expected to go through the mentorship programme at least once a term but that should not prevent the mentor and mentee from meeting if there is a need to do so.

The lecturers should mentor students who are in their second and third year of a junior degree. Senior students should also be assigned to the first-year students as their mentees. They should also be expected to attend the mentorship programme once a term and be allowed and encouraged to meet whenever there is a need. The system should allow the mentors and mentees to report progress and needs as well as requesting support when necessary. Incentives, in the form of points or a minor monetary allowance, should be given to all mentors since the mentees would have received their incentives in the form of bursaries. Postgraduate female students should also be allocated mentees who are on lower levels than themselves, depending on the numbers and needs of both mentors and mentees.

To sustain the retention of women in the STEM fields, there should be databases of women in these fields, maintained by universities, in order to trace the whereabouts of their alumni students. Furthermore, universities should hold STEM fields' alumni events every year, to motivate and encourage women in the STEM to stay and grow within these sectors.

The databases should also reflect the numbers of young women who underwent the programme from its implementation date, the mentors that have retired, and deaths of both mentors and mentees. These statistics would be compared with the numbers targeted by the programme as well as the actual number of mentors and mentees in the programme for each year. In the case of loss of mentors and mentees, through retirement, resignation or death, the system should allow for replacements, in order to reach the target.

Lastly, universities, as the main institutions for research, may further conduct research on how to strengthen and sustain the programme. Emerging issues would also have to be integrated with the planning and implementation processes, in order to ensure that there is no stone unturned in the effort to improve the participation of young women in the STEM fields. Other research institutions may also be in collaboration with universities, to share resources in terms of costs, human resources and information. Research conducted may even lead to a review of the programme at some stage, to ensure relevance and sustainability.

6.2.4.3 South African government

Based on its own NDP 2030, the South African government has a greater and more important role to play. Besides the role of the Department of Basic Education (DBE) and Higher Education and Training, the departments of Science and Technology (DST) and Women have a stake in the i-STEM programme. These departments may integrate the implementation of i-STEM in their medium-term strategic framework (MTSF), since it reflects their mandates directly, though differently. They may share the recommended costs (funding scheme) for the 60% target of young women who will be studying in the STEM fields by each contributing 10% of the cost for identified young women while the remaining costs, i.e. 20%, could be shared between the university concerned (10%) and the partnering STEM private sector companies (10%). The DBE and DHET are responsible for the delivery of quality education in schools and HEIs in the country and might assist the i-STEM programme while implementing their mandates.

The delivery of quality education in this study is about improving the participation of young women in the STEM fields that are scarce but also critical for the country's economy to grow. Quality education also implies the kind of skills that are most

relevant to the era of global warming and security of food supply, and that need to be prioritised. The main roles of the DBE and DHET in this programme will be to identify female students in high schools, prior to them registering at a university. This would have been done as a process that started from Grade 10, where learners in high schools are expected to choose subjects according to the careers that they intend to study for beyond Grade 12.

The DBE will be expected to partner with the DHET and intentionally support these girls with motivational and mentorship programmes. At least once in a term, the i-STEM, first and second year university students, will be expected to visit high schools, to motivate the up-coming incumbents of this programme. They will be the mentors and motivators of high school girls who are studying the STEM fields and will be afforded points every time they visit schools and attend to the schoolgirls in terms of information and support. Each young woman (university student) would be expected to mentor at least two high school learners. They would also be expected to identify problems, together with the learners and the STEM teachers in schools, find solutions as well as write reports on their visits. These reports will be consolidated and shared with the principals of the schools concerned.

Part of the DST's mandate is to ensure the transfer of STEM skills to the next generation and the use of technology to advance services delivered to different recipients in the country. The ever-changing technology needs young people who are empowered to find solutions for the current problems that the world, and in particular South Africa, is facing, e.g. drought, heat waves, shortage of agricultural products, renewable energy, etc. The DST may therefore also develop, in the absence of one, a young women-specific bursary system, where only young women will be granted funding applied for on merit. The Department could also forge partnerships with private sector companies and apply with the South African Revenue Services (SARS), through the National Treasury, to offer them a rebate of up to 10% on their tax returns, when they assist young women to study the STEM fields at South African universities. Agreements of this nature may also include, where possible, clauses where beyond their studies, students will be granted internships for experience in such companies as a way of repaying the bursary as well as possible employment opportunities.

The Department of Women is responsible for the protection of the rights of women as well as ensuring their empowerment and development. Because of its mandate of coordinating programmes on the empowerment of women which are hosted by other departments, this Department is therefore well-positioned to coordinate the activities of the i-STEM programme, advocate for it and also build capacity on issues of gender, since young women are part of its constituency. With its authority and the gender indicators, the DoW will ensure the continuous monitoring of the smooth implementation of such indicators within the activities of the programme as well as the evaluation of the impact it has on young women, with the aim of learning, correcting and strengthening the processes. Officials who will drive this programme will be from the Monitoring and Evaluation section of the DoW who are already performing this function for other related initiatives, for the complete success of this programme.

The Department of Monitoring and Evaluation (DPME) in the Presidency, has a directorate responsible for the advancement of young people, the Youth Development Directorate. Because of its mandate and location within government, the DPME has the authority to hold other government departments accountable for delivery on their mandates. This department monitors and evaluates the performance of various departments against their mandates and allocated budgets. Monthly meetings would be coordinated here and progress by other stakeholders be reported at these meetings. This department would incorporate the indicators of the implementation of the i-STEM programme, which are in line with the South African government's outcomes 4, 5 and 12, which are 'Decent employment through inclusive economic growth'; 'A skilled and capable workforce to support an inclusive growth path'; and 'An efficient, effective and development-orientated public service'. The i-STEM's contribution to the above outcomes will also address the achievement of the millennium development goals (MDGs), some of which are directly related, e.g. Outcome 4 with MDG 8. The other additional MDGs that will be catered for by this programme are MDGs 7, 9 and 13, i.e. 'Affordable and clean energy', 'Industry, innovation and infrastructure' and 'Climate action'. Directly and indirectly, the STEM fields have the potential for innovations to address the concerns of the outcomes and MDGs as well as other related legislative obligations.

One leg of the DPME's Youth Development Directorate is the National Youth Development Agency (NYDA), whose mandate is to mainstream and integrate youth development for sustainable livelihoods. The NYDA has advocacy programmes that empower young people on their rights and also builds capacity on issues that involve the youth, by engaging with young people themselves, identifying their day-to-day needs, in order to include such concepts when planning for service delivery in that regard. The NYDA's role in the i-STEM programme will be to identify young women who studied the STEM subjects but are currently out of school, in both urban and rural areas, who may be assisted to join the programme.

One other prospective partner, which is a key element of the i-STEM programme, is the Department of Public Works (DPW). Since most of the STEM disciplines require students to do practical work as part of the qualification, it is necessary for them to be offered that opportunity by making some vacancies available for such practical work within government, as the main employment provider. It is also envisaged that beyond their studies or after their junior degrees, students will need to be part of the government-driven intern programme for experience in the chosen field, which is often a challenge for young people when they seek permanent employment, especially in the private sector. This Department should enable the i-STEM a chance to have that experience while it would also benefit from the fresh skills brought about by these interns. Partnership will therefore be forged with the DPW, based on that and other opportunities that may not be clear at this stage, for the programme as well as i-STEM students and graduates.

6.2.4.4 Corporate sector

Private sector companies identified by the DST will partner with universities and make presentations during the orientation programmes for the new student intake at the beginning of every year. These presentations will inform students on the i-STEM programme whereby young women are invited separately and recruited to join the STEM fields.

Relevant information and the benefits of these fields will be presented by the CEOs of the companies themselves and what companies commit to provide to a particular number of young women, should they choose specific courses within the STEM fields. Companies will be trained, in order to ensure that their presentations are simplified but

genuine, and presenters are approachable to young women who are prospective STEM students. The presentations would include information on funding that will be provided, practical programmes during studies, internship programmes beyond studies, as well as possible employment when all programmes are completed. Companies would also be part of the mentorship programmes and quarterly meetings where the students' needs will be identified, progress outlined and the way forward designed.

6.2.4.5 South African communities

Communities within different municipalities of the country, urban and rural, will be visited at least once a year whereby awareness will be raised on the need, benefits and future of the STEM fields. The awareness campaigns will be a collaborative effort between relevant stakeholders in the STEM fields as per the i-STEM Programme. These campaigns will be held at identified high schools where there are girl learners who will also take part in the presentations and activities. These activities will range from short presentations in the languages preferred and understood by each community, dramas by the learners as well as talks by school governing body members (SGB), who would have been trained on the main message. There will be one generic presentation for all campaigns, to be circulated in order to ensure the same message is publicised throughout all communities. This will be in different languages according to the communities visited, e.g. English, Venda, Xhosa, etc.

6.2.5 Funding of i-STEM programme

As part of the Gender Mainstreaming Strategy, with gender responsive budgeting (GRB) as its vehicle, stakeholders within government will be trained on how to infuse and mainstream the GRB in their annual budgetary planning. GRB is a portion of the budget within an organisation, which is intentionally allocated for the advancement of women as beneficiaries of that institution.

For some, GRB is already planned and implemented, though on small scale or for other related programmes. In such cases, processes will be strengthened, as per the need of the institutions. Key government partners, i.e. DST, DHET, DoW and DPME and/or NYDA would be required to each contribute 20% of the cost of the programme each year, in line with the requirement of their mandates. Each participating university

would contribute 10% of the cost while the remaining 10% would be contributed by the private sector company that will be partnered. These stakeholders will be expected to pay the costs of one group of students for a three (3) year cycle consistently, after which a new group will be introduced to the programme.

The above funds would cover the following:

- i-STEM programme–100%
- Induction programme; 3 months–20%
- Mentorship training–10%
- Programme implementation–50%
- Monitoring and evaluation–10%
- Review and re-planning–10%.

These partner departments and other relevant ones will be requested to disburse some of the resources in the form of bursaries and scholarships that are already allocated, to be made available towards supporting the implementation of the i-STEM programme. In addition to that, partnerships would be forged with local and international donor organisations, in order to encourage them to direct their contributions to the implementation of the programme, without having to start new initiatives that may duplicate the efforts of i-STEM.

6.2.6 Stages of the i-STEM programme

The stages outlined hereunder will be executed sequentially, in order to allow smooth implementation of the i-STEM programme. Emerging and contextual issues that are related or may inhibit the processes of this programme should be assessed throughout the stages and be addressed or embraced if possible.

6.2.6.1 Phase 1: identification

DBE and DHET will be required to identify the learners who will be mentored from Grades 10 to 12, in preparation for full participation in the i-STEM programme at universities. This will be done in line with the principles as per the mandates of these two departments. On the other hand, the DHET will need to identify and forge relationships with relevant universities, in terms of location with the participating

schools and related matters. The participating universities, as part of the agreement with the DHET, will be expected to identify young women according to the set criteria and those who have shown interest but who also qualify, in their first years at university. Universities will also identify the relevant STEM and prospective mentor lecturers as well as the second and third-year students who will be mentoring the school learners.

Officials who will be assigned to drive the programme within participating government departments and the NYDA (if necessary) will have to be appointed formally, as a sign of commitment, with delivery on the programme reflected in their performance agreements for the sake of accountability. Government and university partners will also be required to identify private sector companies that will participate in the programme. All appointees will be expected to sign binding contracts and commit for at least one full circle, i.e. three consecutive years. After a full circle, the partners as mentioned above will be required to identify new candidates for the next cycle.

The i-STEM aspires to accommodate as many young female students as possible and be robust in that regard. However, the availability or lack of funding will determine the numbers of young women to be taken into the programme per cycle. The aim is to have 60% of young women registered as STEM students in each university every year, for at least six consecutive years. This would balance the numbers of young women and young men in these fields, since the number of young men is currently high, as outlined in the second chapter of this study.

6.2.6.2 Phase 2: induction

During the first and the third Saturdays of March, the i-STEM programme will be dedicated to the induction of government officials, participating lecturers and students, as well as identified learners. Sessions will be held for six hours of contact time. Pockets of induction will be structured according to the roles of the participating partners although certain parts of this programme will be generic. The first session will outline the purpose, objectives, background and activities of the programme, all in theory. During the second and last session of the induction, what was discussed in the first session will be role-played practically by examples, in order to simplify it for all

participants. The last session will also be used to debrief, consolidate and summarise activities and information shared during the first session.

The induction programme will be conducted in every year of a cycle. During the induction period the programme will be structured in such a way that it allows for the integration of emerging issues and identifies, as well as embracing the needs of individuals. The induction programme of every year will discuss the challenges of previous years, with the intention of correcting mistakes and proposing solutions with a view to future progress.

6.2.6.3 Phase 3: implementation

(i) Planning

It is anticipated that the first planning session for the implementation of the i-STEM will be done from July to September of 2019, in anticipation and preparation for the intake of the first group of young women students at the beginning of January 2020, after the release of the Grade 12 results. The intake will, however, be finalised after the orientation programme, where students, in particular young women, will be introduced to the i-STEM programme, the opportunities it brings as well as the benefits of the STEM fields for them. At first, each university will be expected to register 10%, in addition to their normal percentage of young women in the STEM fields. Young women will be assisted to apply and register for the i-STEM programme.

Subsequently, planning would take place earlier, from July for the following academic year, in order to allow for the smooth implementation of the programme and its future progress. This would ensure that challenges of the previous year are addressed as well as embracing emerging issues. Planning will be done by all stakeholders represented, to ensure that all aspects of the programme, including the roles of partners, are integrated. Planning will cover projections of the next two years, to complete the first cycle, followed by a three-year planning session for subsequent years. In the beginning, the mentor: mentee ratio would be 1: 5, including the teachers of participating schools and the lecturers. The ratio for students will be 1:2, as a maximum, to allow them enough time to focus on their own studies.

(ii) Goal setting/Road-mapping

The planning session will be guided by the main goal of the i-STEM programme, i.e. to improve the participation of young women in the STEM fields in South African universities. All other embedded goals will be set to guide the activities of the programme in such a way that they do not clash with those of the participating universities, or of other key partners. Some goals may be added to those outlined in Table 12.

Table 18: i-STEM programme management plan

N	Item	Activities	Time frames	Progress indicator
1.	Appointment of implementing staff	Identification and appointment/ secondment of officials/staff by different stakeholders	May to June	List of implementing staff and signed letters of appointments and contracts
2.	Planning	Monthly meetings by all partners	July to September	Management Plan
3.	Identification of students	Selection of deserving, prospective students by universities	October to January	List of young women to study the STEM fields
4.	Budget	Allocation of the budget for the i-STEM programme by partners, on Treasury and universities' guidelines	October to December	Signed documents on budget allocated to the i-STEM
5.	Roles and responsibilities	Roles and responsibilities of different partners outlined	July to September	List of roles and responsibilities of all partners
6.	Mentor-mentee schedules	Schedules for meetings of mentors and mentees and report submission dates	Monthly meetings from February and quarterly	Mentor-mentee schedules

			reports submissions	
7.	Implementation of i-STEM programme	Implementation processes unfolding, including participation of i-STEM representatives in national and international conferences on STEM and/or United Nations Conference on Climate Change	February to September	Reports, attendance registers, minutes

These activities would be repeated every year and three-yearly for each cycle. They are not cast in stone, as emerging issues will be integrated to keep the programme current and relevant. In the case where some activities need to be replaced, that will be discussed with the participating stakeholders, including young women themselves, as the beneficiaries of the i-STEM programme.

(iii) Advocacy

One of the most powerful tools of the i-STEM programme is advocacy. In order to reach the wide range of young women, even before they decide on a career, digital media, as the main channel of communication for the youth, will be used to post information and the activities of the i-STEM programme. Advocacy pamphlets will be developed, with the logos of all partners, and be distributed in the cafeterias of different universities, schools and even at the malls, for access to all community members. The development of the advocacy material will be budgeted for, including paid media, e.g. television and print media. Churches will also be targeted for the dissemination of information on the programme. Advocacy visits will be paid to different institutions for short presentations, especially where prospective partners are targeted, as well as for sourcing funding. The STEM companies are a natural target for partnerships or only for support, especially in the provision of women mentors for the programme. Both international and local conferences and summits will be used as platforms to advertise the i-STEM programme.

Seminars on relevant topics within the STEM fields will be organised at which local and international presenters and panels will be requested to participate and these will be attended by mentors of the i-STEM programme, i.e. contracted lecturers, students (both mentors and mentees) as well as the teachers at schools that are adopted by participating universities. These seminars will differ from the normal ones in the sense that there will be a session for networking, where the participants will have opportunities to hold conversations with the presenters. Commissions, whereby one presenter will be allocated a maximum of 10 audience members, will be organised as part of the said seminars.

A simplified crash course on the aspects hereunder, will be organised and held from time to time for the partners to stay relevant and be conversant with the latest trends, as well as to attract more young women into the programme.

- **Academic technological programmes**

  Since the key concept of the i-STEM programme is the STEM fields, there will be a need for all participants, even those who are not academics, to undergo a crash course on the use of technology, in order to create a technological atmosphere for both internal and external clients. The latest research programmes will be sourced and officials will be required to use them regularly in order to be able to provide assistance in time of need. The information system used for the programme should also be of a high technological standard and accessible to clients. Regular updates of the system will be done, to keep abreast of changes in the industry.

- **Gender mainstreaming**

  The i-STEM programme is concerned about the current gender disparity within the STEM fields in South African universities, hence the need for it to assist in improving the participation of young women in those fields to be on par with that of their male counterparts. As a result, the partners need to understand gender issues in general and their effect in the STEM fields in particular. For that and related issues, partners should be trained on gender mainstreaming and its processes.

The most important aspect of gender mainstreaming that needs to be understood is gender-responsive budgeting. In order for partners to contribute financially to the programme, the need to budget keeping young women's issues in mind is necessary, e.g. the fact that young women need sanitary towels every month, something that their male counterparts do not need at all, needs to be borne in mind when bursaries are budgeted for. This is a minor element of the i-STEM programme but since it resonates with young women, it has to be included. Therefore, gender mainstreaming training is also necessary for the smooth implementation of the programme.

- **Policy development**

One of the objectives of the i-STEM programme is to ensure that the improvement of young women in the STEM fields in South African universities is deliberately encouraged and enabled through policy development and integration. It is, however, envisaged that the partners of the programme at some stage will have to cooperate with government stakeholders, to outline and negotiate processes in that regard.

In view of the above, the i-STEM representation in the policy development processes should be knowledgeable and there also should be a clear understanding of the legal procedures. This requires empowerment and skills development in policy development before such initiatives start. Policy development will therefore be one skill to be provided to the identified members who will then as a matter of course be nominated to represent i-STEM in such cases.

- **Project management**

The i-STEM programme is an extensive project itself and needs to be properly managed if it is to be sustainable. The partners will have to put in place a mechanism to properly manage this project in a way that will ensure good results. Project management will unpack the modalities on how to roll out this with specific milestones in mind.

- **Curriculum design**

The effort must be made to influence curriculum design so as to enable access of young women to the STEM programmes. This must include access to the necessary resources that will enhance their study.

The introduction of practical practitioners to guide and support young women must be imbedded in the course design. The contracts will therefore set out such matters as the number of core courses and electives, the teaching load and duties of each mentor. In order to have a uniform way of implementing this, mentors will be taken for a short course, even if it is an in-house crash course on curriculum design.

- **Change management**

Socioeconomic transformation, to which the i-STEM aspires, is a product of change. In order for this programme to turn the situation around, i.e. increase the number of young women in the STEM fields, the way things have been taking place has to change, which is a necessary but uncomfortable process. It should be seen as an effort to ease the environment within the STEM fields. Therefore, change management will be one of the empowering programmes, to enable participants to understand and accept change.

- **Leadership**

The implementation of such an important and life-changing project requires visionary leadership that will take into account the implications for the failure or success of the project. The necessary willingness to embrace change and turnaround the status quo to promote young women's access to STEM fields and the throughput will be dependent on the type of leadership available within the programme. Transformational leadership will be a key determining factor to bring about change in the way the stakeholders respond to the emerging challenges that contribute to the registration and completion number of young women within the STEM fields.

- **Peer-counselling**

  The STEM fields by their nature bring about stressful conditions because of the perception that they are difficult to study. The young women must be assisted through an avenue that will provide a sound and safe environment to receive counselling. This will yield better results if it is conducted by their peers who will be able to share experiences and mechanisms to overcome such challenges.

  Peer counselling can create an atmosphere of acceptance and an acknowledgement that the challenges are not insurmountable. Hence the student mentors and mentees will be taken through a course to ensure that there is uniform practice throughout the i-STEM programme.

With time and availability of resources, the i-STEM programme will have to develop its own publication, in the form of a magazine that will be published every three months. This magazine will publish the latest news on the STEM fields, .e.g. new technological activities and gadgets that can add value to the lives of individual; the names of mentors and their mentees, as well as the processes they follow to develop the skills and knowledge of the mentees; progress made as a result of the i-STEM programme and its developmental processes; as well as the statistics of students who have graduated and those that are about to graduate through the assistance of the i-STEM programme. Sponsors will be sourced, in order that the magazines may reach learners in both urban and rural areas, at universities and high schools in different provinces. Students who have been part of the i-STEM programme will also be encouraged to write articles on their journey within the programme and use this publication to motivate other young women to join the i-STEM train without any fear.

In order for any initiative to be sustainable, there is a need for policy directives that will anchor its roots onto fertile soil, in this case, youth and women development programmes in the country. As a result, the DST, as a prospective lead government department, will be requested to initiate a policy development or integration process that will embrace the objectives of the i-STEM programme. The stakeholders of the i-STEM programme, with their policy development skills that would have been transferred through training as discussed above, will have to be part of discussions in the development/integration processes of the i-STEM programme policy. This will

enable the processes to include issues that have been bothering the implementers of this policy. It would also make it easy for subsequent implementers to have policy covering when needed, with a view to future developments.

Once the policy is in place, the i-STEM programme would be a law on its own and be a binding obligation to many government and private sector stakeholders, as well as civil society organisations, that have the mandate and interest in the development of young women in general and the improvement of their participation in the STEM fields in particular.

(iv) Mentorship

All i-STEM students will be assigned a mentor for the duration of their participation in the programme. First-year students will be mentored by second-year students who will in turn, be mentored by third-year students. The third-year students will be mentored by the lecturers. As for the high school girls who have been identified as prospective university students, they will be mentored by the first-year university students and monitored by their teachers.

The role of the mentors will be to guide the STEM activities of the mentees and together they will set up objectives that the mentee will have to meet at a given time. The mentor will then keep track of their agreed developmental milestones as planned. It is envisaged that mentors will be able to walk step-by-step with the mentees, since they would be only a year ahead of their mentees. This will assist the mentors to relate well with the experiences of the mentees and be able to find solutions that will suit the mentees since their age gap would not be far apart. Mentors will also assist the mentees to develop their personal timetables for activities outside university work. These timetables will include activities for relaxation and pleasure, which are beneficial to the mentees' personal development, e.g. physical and mental exercises, management of financial and personal affairs etc. and any other challenges that would be a risk in hindering the professional development of the mentees.

Available vacancies for mentors will be advertised in the government and universities' publications, at national level and also on various platforms like electronic and print media, in order to solicit applications from experts around the country. The main

partners, universities, will then take the process forward, through their normal student selection processes, to identify students who qualify to be part of the programme. The advertisement will indicate that the posts are contractually bases and not permanent.

(v) Piloting the i-STEM and retaining participants

It is envisaged that during the first cycle of the i-STEM programme, implementation will be challenging as the programme will be piloted and tested. Support by external female mentors, who are currently operating in the STEM fields, will be sourced through contractual work. These mentors will be a sample that the STEM fields are an area suitable for women as well as for men. Mentors will function as role-models of the programme and motivators of all mentors and mentees of this initiative. These mentors will assist in developing the mentorship programme manual, with information on all their experiences in the STEM fields. However, these role-model partners will also be developed to meet the expectations of the i-STEM programme. This will be included in the contract, to avoid any misunderstanding.

The following are initial activities of the programme:

- All participants will be expected to sign a contract, as an indication of commitment.
- Funding will be used for registration costs for participation in the sub-programmes, i.e. induction, mentoring, development and planning.
- Implementation costs include non-formal activities, i.e. transportation of mentors for their meetings with the mentees, refreshments for such meetings (if necessary) and payment of mentors.

(vi) Managing the implementation of the i-STEM

The following activities will be part of the management of the i-STEM programme. Any emerging issues during implementation will be integrated and also managed in order to ensure the smooth unfolding of this initiative, as follows:

- As the i-STEM programme is not a stand-alone, it should be seen as a support tool for STEM disciplines in the university education system. Therefore, all its sub-programmes should be viewed as an item of the annual planning process in those fields.

- The implementation of the i-STEM is a value-adding capacity-building project that involves all partners. Therefore, a strong management capacity is expected from all stakeholders.
- Management and coordination at different institutional levels will be undertaken by appointed persons and officials.
- Short reports will be submitted quarterly to the main office of the i-STEM, followed by comprehensive reports at the end of every academic year.
- Quarterly reports will be used for re-planning subsequent terms, to avoid committing the same mistakes in every quarter.
- Participating universities and/or the DST, as the overseer, will provide at least one office space for the administration of all activities of the i-STEM programme. The appointed/seconded staff members will utilize these offices for daily use and for easy accessibility of stakeholders.
- An annual meeting will be held to review the activities of the i-STEM during the year and the outcome be used to strengthen processes.
- The DPME will be expected on a quarterly basis to monitor and evaluate the implementation, through the use of the set indicators and advise on the way forward.

(vii) Exit plan

In their third year of the i-STEM programme, participating students are expected to indicate their plans, i.e. whether they are exiting the education system for the corporate world. It is also envisaged that beyond their junior degree levels, students will remain in the programme as postgraduate mentors to the third-year students. Should they wish to leave for the world of work, it is also expected of them to stay mentors for students who are still at undergraduate level or even be role-models who come to deliver motivational talks for the i-STEM students on request.

Students with a strong performance history in terms of their studies and mentoring skills will be retained as facilitators of developmental workshops for participating stakeholders. Should a student wish to drop out of the programme, she will have to repay costs as arranged. That would have been signed for, as part of the conditions of the contract.

6.2.6.4 Phase 4: impression

Beyond the implementation of the i-STEM programme, participating universities will be expected to provide comprehensive reports on the progress of the i-STEM as well as its impact analysis on the performance of young women students, in comparison with reports of the previous years. The reports will be a consolidation of the mentors' and mentees' reports as well as different areas of the STEM fields within these institutions. These reports will also inform the programme on whether young women are attracted in bigger numbers to the STEM fields or not. These reports will function as baseline information in the planning for subsequent years. At the end of a cycle, i.e. three years of the programme, a database of all participants of the i-STEM should be available, as a reference of statistics of young women who took part in the programme from its inception onwards. This will serve as a quantitative yardstick that will help to measure the contribution of the programme in increasing the participation of young women, in terms of numbers, as follows:

- Number of young women who joined the STEM fields as a result of the i-STEM programme;
- Number of mentors in each cycle (3 years);
- Number of mentees who were mentored in each cycle;
- Different stakeholders within and out of government;
- Participating universities and schools;
- Number and names of workshops provided by the programme;
- Staff members and officials who run the programme on a full time or part-time basis, including those who are seconded or co-opted;
- Amount of money spent in a cycle.

The database will also serve as a qualitative tool to measure the value and impact that the programme had, as follows: information on the credentials of participants; their positions within the programme and the roles they played; impact on the lives of young women in the STEM fields; and gender equality in those fields as well as in the overall economy of the country.

6.2.6.5 Phase 5: integration

The implementation process of the i-STEM and the reports written will inform this part of the programme about the blockages and contextual factors that hinder the smooth unfolding of processes. The framework of the reports will be structured in such a way that the causes of the above challenges are identified and recommendations made to resolve such issues. These recommendations will be discussed, considered and integrated into the processes of the implementation in future. Emerging issues identified during the implementation of the programme, which seemed to be necessary towards the relevance and strengthening of the i-STEM, will also go through the processes that the challenges experienced and be embraced if regarded as adding value to this programme. In cases where certain activities which were initially part of the programme and appear to be obstructions during implementation, they will be eliminated through the same treatment as the above challenges.

The process of integration will also be applied where activities of the i-STEM need to duplicate the normal processes of different institutions. For instance, in the case of budgeting, which is an annual process of the organisations that will be funding the programme, integration of a gender-responsive budgeting, dedicated to i-STEM will be encouraged. What would be left for the programme would be to integrate the allocated budget into i-STEM's own annual budgeting activities, including its management. On the other hand, the resources that are already available in the partner organisations, like universities, that of recruiting students, for example, which is done annually and does not require any additions, will be used as an advantage to infuse the recruitment of the i-STEM students, besides its own recruitment processes as outlined in the previous paragraphs. This coherence is encouraged by the NDP
2030, to enable institutions in general, to achieve their goals but also the youth in particular, to realise holistic youth development for young women, as part of that community.

The role of the Sector Education and Training Authorities (SETAs), as indirect partners, will not be ignored as they ensure the training and development of the citizens of South Africa in general, in various sectors. The relevant SETAs, e.g. the education training and development practices (ETDP) will be approached to contribute financially to the implementation of the i-STEM programme through the accredited

training of mentors and mentees, if possible. With a share from the National Skills Fund, the SETAs will be requested to contribute substantially towards the implementation of this programme and also integrate its budgeting through the medium-term expenditure framework (MTEF), in order to secure it through the National Treasury processes and prescripts. The programme will then work with other key partners to direct unfolding processes, in order for i-STEM to benefit maximally from this initiative.

6.2.6.6 Phase 6: intensification

For the intensification and strengthening of the i-STEM, more research will be conducted with the implementation of this initiative. The research will be based on areas that need to be strengthened and those that emerge when processes are unfolding. The main aim of this research will be to keep the programme current and relevant by ensuring that all issues that have been, or serve as, risks towards the improvement of young women's participation in the STEM fields are addressed. Continuous research bears continuous development as areas of development are identified and embraced as part of the implementation of the programme.

As part of the programme, participating universities will be expected to adopt schools that they will develop on a continuous basis, e.g. whereby the STEM teachers will be developed with courses organised by such universities. This process will empower teachers and learners of the adopted schools to meet the STEM requirements of universities. At the same time, universities will be able to identify, together with the teachers of the adopted schools, the needs of the learners in such schools. Therefore, such needs will be addressed before the learners enter the universities, beyond their schooling period, which will provide a smooth transition for them, from school to university.

Another benefit of the adoption of schools by universities will be a sharing of resources between these two institutions. In some cases, universities will be expected to adopt far more than one school, a combination of urban and rural schools and coordinate the sharing of skills and resources among these schools. Developmental courses conducted by the university will gather the teachers of all these schools in one room

where they will share information among themselves. An arrangement of shared teaching and shared lessons is also encouraged, to allow teachers to share their expertise. In the case where one teacher excels in teaching a particular theme or topic, she might be invited to go to the sister-school and teach such lessons to the learners of that school. An element of mentorship, by lecturers of teachers is also encouraged in this part of the programme, whereby university lecturers of these participating institutions will adopt the STEM teachers who are already employed in the school and mentor them through processes that will add value to their learners while within the school system but also beyond it when they join the tertiary system, in particular universities.

Since the ETDP SETA annually supports the development of university lecturers and teachers as part of its annual performance plan targets, funding allocated to such activities may as well be directed to support the implementation of the i-STEM programme, by empowering all staff members, temporary and permanent, including contracted and seconded officials as well as the mentees on the key supporting programmes that add value to the main one, i.e. the i-STEM programme.

6.2.6.7 Phase 7: ignition

In the beginning of the i-STEM programme mentors' posts would be temporary, since the role itself is not a full-time job. However, with time and the availability of resources, the participating institutions will be encouraged to employ several officials, mentors and lecturers on a permanent basis and infuse the i-STEM programme as an independent section within these organisations. With more research conducted to support the initial processes of this programme, the need to grow can never cease to occur. The Presidency, through its NDP 2030 and Government Outcomes, will be requested to adopt the i-STEM programme as its own, embracing other related issues that would have been identified as priorities in government.

United Nations Organisations, e.g. United Nations Children's Fund (UNICEF), United Nations Women (UN Women) and United Nations Development Fund (UNDF) will be approached for partnership, through government. These and other related UN organisations will be requested to link the i-STEM programme with initiatives of the same nature globally, in order to take lessons from other developed countries. The

other reason is to expose i-STEM students to the world and provide them with unique and extremely valuable experiences and opportunities. Some activities for this approach will be the introduction of the i-STEM International Student Exchange Programme, which will see South African young women going to study abroad in exchange with young women students from developed countries, coming to study for agreed periods of time in South Africa.

The exchange of young women students will also see the i-STEM Mentorship Exchange Programme in place. The i-STEM mentees will be provided with an opportunity, while in other countries, to be mentored by experts from those countries. Since mentoring is a cooperative activity, mentors from South Africa will also gain a lot of experience from mentoring the students participating in the exchanged programme while they study in our own country. The forging of partnerships with the international world in that regard, will put the i-STEM programme high on the global economic market, and even higher, will be the status of the South African government. To see young women in this country living sustainable lives brought about by opportunities in the STEM fields, thus gravitating towards gender equality would be one of South Africa's greatest transformational achievements. The i-STEM programme is a golden vehicle towards holistic youth development.

6.3 CONCLUSION

This initiative, the i-STEM programme, was developed as a result of the findings of this study. It is 'An Awareness Programme to Improve Participation of Young Women in the Science, Technology, Engineering and Mathematics (STEM) Fields in South African Universities'.

The various steps have been outlined as an effort to address the needs that were identified when the study was conducted, i.e. young women's needs to improve their participation in the STEM fields in South African universities. Although the study was conducted with young people as a community, i.e. young women and young men, the target and the beneficiaries of this programme are young women.

Other participants of the study were the officials of the national government as the government is responsible for the development and amendment of policies. As a

result, the government's input into the i-STEM programme was essential. The inputs of lecturers and university admissions administrators were also sourced as they form part of the implementation of this programme. Therefore, a sense of ownership was created for young women as beneficiaries and young men who have sisters and mothers as members of their communities.

The i-STEM programme is not an island on its own but needs the support of other programmes for its smooth implementation. At the same time, this programme is a work in progress and in the future would accommodate more implementation inputs, as well as embracing emerging issues along its long and yet worthy implementation journey.

BIBLIOGRAPHY

Accenture Consulting Technology Outsourcing and Women Invent Tomorrow. 2014. Powering economic growth: Attracting more young women into science and technology. Silicon Republic.

Agu, N.N. & Omenyi, A.S. 2013. Gender enrolment status in higher education courses: A situation assessment and analysis of a south-eastern federal university. *Journal of Emerging Trends in Educational Research and Policy Studies.* South Eastern Federal University 4(3) June: 517–24.

Akinsowon, O.A. & Osisanwo, F.Y. 2014. Enhancing interest in sciences, technology and mathematics (STEM) for the Nigerian female folk. *International Journal of Information Science*; 4(1):8-12.

Aldridge, A. & Levine, K. 2001. *Surveying the social world: Principles and practice in survey research.* Philadelphia: Open University Press.

Auston, S. & MacPhail, F. 2011. *The Economy and Labour Relations Review*; 22(3): 41–158.

Baltodano, J.C., Carlson, S., Jackson, L.W. & Mitchell, W. 2012. *Networking to leadership in higher education: National and state-based programmes and networks for developing women*. Thousand Oaks, CA: Sage.

Besecke, L.M. & Reilly, A.H. 2006. Factors influencing career choice of women in science, mathematics and technology: The importance of a transforming experience. *Advancing Women in Leadership*. Online Journal Volume 21. www.advancingwomen.com/awl/summer2006/Besecke_Reilly.html [Accessed 27 March 2017].

British Council India UK Science & Innovation Network, India and Department of Science and Technology. 2015. Women in Science, Technology, Engineering and Mathematics (STEM): A case for intervention.

https://www.britishcouncil.org/sites/default/.../women_in_stem_-final_programme.pd. [Accessed 12 February 2018].

Bryman, A. 2004. *Social research methods.* (2nd edition). US: Oxford University Press.

Botha, J. Kiley, J. Truman, K. & Tshilongamulenzhe, M.C. 2013. (2nd edition). *Practising training and development in South African organisations*. Cape Town: Juta.

Buabeng, I., Ampiah, J.G. & Quarcoo-Nelson, R. 2012. Senior high school female students' interest in physics as a course of study at university level in Ghana. *Gender and Behaviour; Ghana: University of Cape Coast* (1) 10 June: 4574–84.

Bulger, R.E. 2004. The responsible conduct of research, including authorship and publication practices. In M. Korthals and R.J. Bogers, Editors. *Ethics for life scientists.* Dordrecht: Springer.

California State University, Northridge (CSUN). *Quantitative sampling*. Chapter 8. www.csun.edu/-hbsoc126/soc4/chapter_8_outline.pdf [Accessed 23 January 2018].

Christiea, M., O'Neilla, M., Ruttera, K., Younga, G. & Medlanda, A. 2017. Understanding why women are under-represented in science, technology, engineering and mathematics (STEM) within higher education. Australia: Queensland. University of Sunshine Coast. A Regional Case Study, Production 27. http://dx.doi.org/10.1590/0103-6513.220516.

Cohen, C., Manion, L. & Morrison, K. 2007. *Research methods in education* (6th edition). London: Routledge.

Corporate Planning and Policy Directorate Natural Sciences and Engineering Research Council of Canada. Women in Science and Engineering in Canada.

www.nserc-crsng.gc.ca/_doc/Reports-Rapports/WISE2017_e.pdf. [Accessed 28 November 2017].

Creswell, J.W. 2014. *Research design: Qualitative, quantitative and mixed-methods approaches.* Thousand Oaks, CA: Sage.

Creswell, J.W. & Plano-Clark, V.L. 2007. *Designing and conducting mixed methods research*. Thousand Oaks, CA: Sage.

Cummings, L.M. 2015. USAID from the American people, gender equality in science, technology, engineering agricultural sciences and mathematics (STEAM) academic pipeline: challenges transferring knowledge to practice. 30 September. https://www.usaid.gov/sites/default/files/USAID-Report-Sep-30-2015-Final. [Accessed 30 September 2017].

Davies, M.B. 2007. *Doing a successful research project: using qualitative or quantitative methods.* New York: Palgrave Macmillan.

Dawson, A.E., Bernstein, B.L. & Bekki, J.M. 2015. *Providing the psychosocial benefits of mentoring to women in STEM: Career*WISE as an Online Solution, New Directions for Higher Education, Wiley Periodicals. Published online in Wiley Online Library No. 171. https://onlinelibrary.wiley.com/doi/10.1002/he.20142/pdf.

Denzin, N.K. & Lincoln, Y.S. 1994. Introduction: entering the field of qualitative research. In N.K. Denzin and Y.S. Lincoln (eds). *Handbook of qualitative research*. Thousand Oaks, CA: Sage.

Denzin, N.K. & Lincoln, Y.S. 2000. *Handbook of qualitative research*. (2nd edition). Thousand Oaks, CA: Sage.

Eisenhart, M.A. & Finkel, E. 1998. *Women's science: Learning and succeeding from the margins.* University of Chicago Press. Https://press.uchicago.edu/ucp/books/book/chicago/W/bo3683343.html.

Elster, D. 2014. First-year students' priorities and choices in STEM studies – IRIS findings from Germany and Austria, *Science Education International*; 25(1):52–59. https://files.eric.ed.gov/fulltext/EJ1022899.pdf.

Erwin, L. & Maurutto, P. 1998. Beyond access: Considering gender deficits in science education. *Gender and Education;* 10(1):59–61. http://textarchive.ru/c-2203694-pall.html.

Freeman, B. Marginson, S and Tytler, R. 2015. The age of STEM: Educational policy and practice across the world in science, technology, engineering and mathematics. New York: Routledge. https://www.routledge.com/...Age-of-STEM-Educational-policy-and-practice-across-t.

Fouad, N.A., Liu, J.P., Cotter, E.W. & Gray-Schmiedlin, I.G. 2014. The impact of economic perceptions on work-related decisions. *Journal of Career Assessment;* 22(2):355–70.

Grissmer, J. Beekman, J.A. & Ober, D. 2014. Gender gap trends in mathematics examinations position girls and young women for STEM careers. Ball State University.http://onlinelibrary.wiley.com/doi/10.1111/ssm.12098/full.

Grix, J. 2010. The foundations of research. (2nd edition). Palgrave Macmillan. https://www.macmillanihe.com/page/detail/The-Foundations-of-Research/?K.

Gutsell, J.N. & Remedios, J.D. 2016. When men lean out: Subtle reminders of child-raising intentions and men and women's career interests. Brandeis University, USA, Tufts University. *Journal of Experimental Social Psychology*; 28-33. USA. https://pdfs.semanticscholar.org/3e46/553440df19429d3a65c6bef024ccad19fab3.pdf.

Hazari, Z., Potvin, G., Cribbs, J.D., Godwin, A., Scott, T.D. & Klotz, L. 2017. Interest in STEM is contagious for students in biology, chemistry, and physics classes. https://www.ncbi.nlm.nih.gov/pubmed/28808678. [Accessed 9 August 2017]

Henning, E., Gravett, S. & Van Rensburg, W. 2002. *Finding your way in academic writing.* (2nd edition). Pretoria: Van Schaik.

Internet. Edited by Shannon de Ryhove: Creamer Media Senior Deputy Editor Polity and Multimedia (www.creamermedia.co.za).

Jakes, P.J. 2013. Dual enrolment as a factor from women transitioning into STEM majors in Montana two-year colleges. University of Montana.

Joppe, M. 2000. *The research process*. http://www.ryerson.ca/~mjoppe/rp.htm. [Accessed 13 May 2004].

Krippendorp, K. 2004. *Content analysis: An introduction to its methodology*. Thousand Oaks, CA: Sage.

Latchanah, C. & Singh, S. An investigation of the challenges faced by women when progressing into leadership positions: A case of the IT division at Barclays Africa Technology (Trading as ABSA) Journal of Management and Administration.

Le Compte, M.D. 2000. Analysing qualitative data. *Theory into Practice*; 39(3):146–54.

Ledwith, S. & Manfredi, S. 2000. Balancing gender in higher education: A study of the experience of senior women in a "new" UK university. Oxford Brooks University. London: Sage.

Macmillan, J.H. & Schumacher, S. 2010. *Research in education: Evidence-based inquiry*. New Jersey: Pearson Education.

Maltby, J.L., Brooks, C., Horton, M., Morgan, H. 2016, Long-term benefits for women in a science, technology, engineering, and mathematics living-learning community. *Learning Communities Research and Practice* 4(1), Article 2, 24 May http://washingtoncenter.evergreen.edu/lcrpjournal/vol4/iss1/2.

Maree, K. & Pietersen, J. 2007. The quantitative research process. In K. Maree (ed.) *First steps in research.* Pretoria: Van Schaik.

Marshall, N. 1996. Sampling for qualitative research. Family Practice. Volume 16 (6), 23 Jan 2019. Oxford University Press, Great Britain 13: 522–525.

Merriam, S.B. 1998. *Qualitative research and case study applications in education.* Revised and expanded from *Case study research in education*. San Francisco: Jossey-Bass.

Miles, M. 2000. *Rethinking gender, empowerment and development*. Pretoria. HSRC.

Mokhele, M.L. 2011. Teachers' perspectives on continuing professional development: A case study of the Mpumalanga Secondary Science Initiative (MSSI) Project. PhD thesis, University of South Africa, Pretoria.

Muchie, M. 2015. 'STEM for African development'. DST/NRF research professor on Innovation and Development, TUT, Human Sciences Research Council Seminar. 7 May 2015.

Naoum, S.G. 2013. *Dissertation research and writing for construction students.* (3rd edition). Canada: Routledge.

National Centre for Education Statistics (NCES) Products, News and Offers. 2013. Projections of education statistics to 2021. https://bookstore.gpo.gov/agency/national-center-education-statistics-nces.

Noonan, R. 2017. Women in STEM: 2017 Update U.S. Department of Commerce, Economics and Statistics Administration. Office of the Chief Economist.

Nqamane, V. 2009. Review: *Millennium development goals (MDG) report*. Pretoria: HSRC.

O'Dea, A. & Corcoran, M. 2014. *Powering economic growth: Attracting more young women into science and technology.* Silicon Republic: Women Invent Tomorrow.

Oloduowo, M.A. 2006. Implications for technological advancement of the nation. *Gender and Behaviour*; (1)4 June: 493–507. University of Ilorin.

Payne, G. & Payne, J. 2004. *Key concepts in social research.* Thousand Oaks, CA: Sage.

Professionals Australia. [Sa]. Women in STEM in Australia: What is the current status of play, what are the key issues and why does it matter? *Gender and Diversity*. Australia.

Ramjee, S., Sibiya, F.G. & Dreyer, K.A. 2013. The gender profile of the South African actuarial profession. *South African Actuarial Journal*; (13):21–37.

Reid, E.L. 2009. Exploring the experiences of African American women in an undergraduate research program designed to address the underrepresentation of women and minorities in neuroscience: A qualitative analysis. Georgia State University.

Reubena, E., Sapienzab, P. & Zingalesc, L. 2014. *How stereotypes impair women's careers in science.* New York: Columbia Business School, Columbia University, Evanston: Kellogg School of Management, North Western University and Chicago, Booth School of Business, University of Chicago. Edited by Greenwald, A.G. Seattle, WA, University of Washington 111 (12), 25 March: 4403–4408.

Satutyanarayana, D.K. & Meduri, B.R. 1982. Advancement and empowerment of women through open distance education. Dr. P. Ambedkar Open University (Braou).

Savela, A.E. & O'Brien, K.M. 2016. Predicting college women's career plans: Instrumentality, work and family. *Journal of Career Development;* 42:155–62.

Shepherd, D.L. 2017. *Gender, self-concept and mathematics and science performance of South African Grade 9 Students.* Stellenbosch Economic Working Papers. University of Stellenbosch, South Africa.

Shin, Y. & Lee, J. 2017. Predictors of career decision self-efficacy: Sex, socioeconomic status (SES), classism, modern sexism and locus of control. *Journal of Career Assessment,* 1–16. doi:10.1177/1069072716658649.

South Africa. 1996. *Constitution of the Republic of South Africa, Act 108 of 1996.* Pretoria: Government Printer.

South Africa. 1996. National Education Policy Act (NEPA), Act 27 of 1996. Pretoria: Government Printer.

South Africa. 1996. South African Schools Act (SASA), Act 84 of 1996. Pretoria: Government Printer.

South Africa. The Presidency. 2009. Situational Analysis of Children in South Africa. Pretoria: Government Printer.

South Africa. Higher Education South Africa (HESA). 2011. Proposal for a national programme to develop the next generation of academics for South African higher education. Department of Higher Education and Training, Pretoria: Government Printer.

South Africa. National Planning Committee. 2011. National Development Plan: A vision for 2030. Brand South Africa.

South Africa. The Presidency. 2011. National Development Plan 2030: Executive Summary. Pretoria: Government Printer.

South Africa. Department of Higher Education and Training. 2015. Staffing South Africa's universities framework: A comprehensive, transformative approach to

developing future generations of academics and building staff capacity. Pretoria: Government Printer.

South Africa. Department of Women. 2015. *The status of women in the South African economy*. Pretoria: Government Printer.

South Africa. Department of Higher Education and Training. 2017. Ministerial statement on the implementation of the university capacity development programme through effective management and utilisation of the University Capacity Development Grant 2018–2020: *Transforming teaching, learning, researching and leading towards enhanced quality, success and equity in universities.* Pretoria: Government Printer.

Tashakkori, A. & Teddlie, C. 2003. *Handbook of mixed methods in social and behavioural research*. Thousand Oaks, CA: Sage.

Taylor, G.R. 2005. *Integrating quantitative and qualitative methods in research.* US: University Press of America.

Terre Blanche, M. Durrheim, K. & Painter, D. 2006. *Research in practice: Applied methods for the social sciences*. (2nd edition). Cape Town: University of Cape Town Press.

Tirfe, T.M. 2016. Challenges of and opportunities for implementing the school improvement programme in the public secondary schools of Iluababor administrative zone in Ethiopia. PhD thesis. University of South Africa, Pretoria.

Tjomsland, M. 2009. Women in higher education: A concern for development. *Gender, Technology and Development*; 13(3):407–27. Los Angeles: Sage.

UNESCO. 2016. Closing the gap in STEM: Drawing more girls and women into science, technology and engineering. Education Thematic Brief. August. (Asia Pacific, UNESCO).

United Nations. 2015. Youth population trends and sustainable development. Department of Economic and Social Affairs Population Division 2015/1, May: 1–4.

Ureksoy, H. 2011. The role of program climate and socialization in the retention of engineering undergraduates. Scholar Commons, University of South Florida.

UWESO Consulting. 2015. Techno-Girl: 2015 Alumni Milestone Report. Johannesburg. South Africa.

White, D.W. 2014. What is STEM education and why is it important? Tallahassee, Florida: Florida A&M University. *Florida Association of Teacher Educators Journal 1* (14):1–9. http://www.fate1.org/journals/2014/white.pdf.

World Bank. 2009*. Literature review on equity and access to tertiary education in the Africa region.* Washington, DC: World Bank.

Xu, Y. 2015. Focusing on women in STEM: A longitudinal examination of gender-based earning gap of college graduates. *Journal of Higher Education*; 86(4), July/August: 489–523. Ohio State University Press.

APPENDIX A

Permission Letter to conduct research in the Department / University

Reference number:…….

Date: …….

To:

The Director General / Rector

Subject: - Request for Mrs Lineo Lynnette Toolo to Conduct Research in March and April 2017

Title: - 'An Awareness Programme to improve the participation of young women in the Science, Technology, Engineering and Mathematics Fields in South African Universities'

I, Lineo Lynnette Toolo, am doing research with Mpho Dichaba, a Professor in the Department of ABET and Youth Development towards a PhD degree at the University of South Africa. We are requesting your permission to allow me to kindly:

- Conduct an interview with you as the Head Administrator of the National Department of Higher Education and Training in South Africa.
- Conduct interviews with three (03) Senior Officials, who are Programme Managers involved with university students and/or curriculum in your department.

The aim of the study is to improve the participation of Young Women in the Science, Technology, Engineering and Mathematics Fields in South African Universities for their socioeconomic sustainability, by finding out why most young women who enrol in South African Universities avoid studying courses in the STEM fields. A bigger number of them enrol for careers in the fields where the skills are oversupplied, adding

fuel into the already burning fire, i.e. a high unemployment rate of young people who are qualified graduates in the country.

Your Department has been selected as one of the institutions, in addition to three Universities for this research, i.e. UNISA, UFS and UNW because according to the World Bank Report (2009: 2) tertiary education, part of which is acquired at Universities, forms a nation‘s foundation for the development of a highly skilled workforce that can compete in the global economy. Since your Department is responsible for the provision of such education, yours and your officials’ participation in this research is important.

The benefits of this study are to design and produce an awareness programme to give directives and enable South African Universities to influence and assist full-time students, in particular young women, to take up careers in the Science, Technology, Engineering and Mathematics (STEM) fields, in the strife to improve their socioeconomic sustainability (through getting and/or creating employment), towards a holistic youth development.

There are no anticipated risks in the conduction of this research. However, should there be any, emerging in the process, I will be in constant contact with your Department in order to manage such.

The contact details of all participants and their preferred way of communication will be kept in order to ensure that they are provided with feedback on the findings upon completion of this research. One copy of the final thesis will be given to your Department as a token of appreciation.

Your usual cooperation and support are highly appreciated.

Yours sincerely

_____

Lineo Toolo (Mrs)
Researcher

APPENDIX B – CONSENT LETTER

Reference number: _____

Date: _____

To:

Director General / Rector

This letter is an invitation to consider participating in a study that I, Mrs Lineo Lynnette Toolo, am conducting as part of my research as a doctoral student, entitled 'An Awareness Programme to improve the participation of young women in the Science, Technology, Engineering and Mathematics Fields in South African Universities', at the University of South Africa. Permission for the study has been given by the Ethics Committee of the College of Education, UNISA. I have purposefully identified you as a possible participant because of your valuable experience and expertise related to my research topic.

I would like to provide you with more information about this project and what your involvement would entail if you should agree to take part. The importance of 'An Awareness Programme to improve the participation of young women in the Science, Technology, Engineering and Mathematics Fields in South African Universities' in education is substantial and well documented. In this interview I would like to have your views and opinions on this topic. This information can be used to improve young women's knowledge of career opportunities that are related to the STEM fields and that such fields are part of the solution to their socioeconomic empowerment.

Your participation in this study is voluntary. It will involve an interview of about 30 minutes in length, to take place at a time convenient to you. You may decline to answer

any of the interview questions if you so wish. Furthermore, you may decide to withdraw from this study at any time without any negative consequences.

With your kind permission, the interview will be audio-recorded to facilitate collection of accurate information and later transcribed for analysis. Shortly after the transcription has been completed, I will send you a copy of the transcript to give you an opportunity to confirm the accuracy of our conversation and to add or to clarify any points. All information you provide is considered completely confidential. Your name will not appear in any publication resulting from this study and any identifying information will be omitted from the report. However, with your permission, anonymous quotations may be used. Data collected during this study will be retained on a password protected computer for 12 months in my locked office. There are no known or anticipated risks to you as a participant in this study.

If you have any questions regarding this study or would like additional information to assist you in reaching a decision about participation, please contact me at 0822024350 or by e-mail at lineo.toolo50@gmail.com.

I look forward to speaking with you very much and thank you in advance for your assistance in this project. If you accept my invitation to participate, I will request you to sign the consent form which follows on (the next page 3).

Yours sincerely

……
Lineo Toolo (Mrs)
Researcher

CONSENT FORM

I have read the information presented in the information letter about the study 'An Awareness Programme to improve the participation of young women in the Science, Technology, Engineering and Mathematics Fields in South African Universities' in education. I have had the opportunity to ask any questions related to this study, to receive satisfactory answers to my questions, and add any additional details I wanted. I am aware that I have the option of allowing my interview to be audio recorded to ensure an accurate recording of my responses. I am also aware that excerpts from the interview may be included in publications to come from this research, with the understanding that the quotations will be anonymous. I was informed that I may withdraw my consent at any time without penalty by advising the researcher. With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.

Participant's Name (Please print):……..

Participant Signature: ……

Researcher Name: Mrs Lineo Lynnette Toolo

Researcher Signature:……

Date:

APPENDIX C: INTERVIEW SCHEDULE

Interview Schedule: Senior Management Officials / Lecturers

(a) Name of participant: _____

(b) Education Status: _____

(c) Date of Discussion: _____

(d) Time of Discussion: _____

(e) Starting Time: _____

(f) Ending Time: _____

Part I: Youth Development

1. How can you define 'Holistic/Sustainable Youth Development?
2. Do you think the Constitution of the Republic of South Africa, Act 106 of 1996 promotes youth development enough and why?
3. Is there a balance in the development of girls and boys, young women and young men in general in South African Universities and what are the reasons for your answer?

Part II: Economic Empowerment and Social Transformation

4. What does socioeconomic empowerment entail?
5. What are young women's basic socioeconomic challenges that are related to your work?
6. Which skills are said to be scares and yet critical to improve the economy of South Africa?
7. How can young women in the Universities participate actively in the economy of the country?
8. What are the requirements for social transformation that this University can contribute towards their achievement?

Part III: Career Choice

9. What do you think is the reason for young people to choose careers in the STEM fields nowadays in the Universities?
10. In your experience, is there a difference in the performance of young men and young women, given equal opportunities, in the course that you are offering?
11. When comparing the STEM and Social sectors, which one has better career opportunities and should be promoted more to young women?
12. What would you recommend to women role-models in the STEM fields in South Africa, when mentoring young women in the same fields in the Universities?
13. Considering the number of young women who are graduates but currently unemployed, would you say South Africa is experiencing an oversupply of jobs in certain fields and an undersupply of in the other fields? If no, what is the cause of the above situation? If yes, how can this University assist in turning this situation around?

Part IV: University Education

14. How can Universities be assisted to improve the participation of young women in the STEM fields?
15. Research shows that the roll of young women at Universities in general is higher than that of young men and that the number of young women is significantly low in the STEM fields than in the Social fields at Universities. What do you think are reasons for that?
16. Does this University have a monitoring tool to determine the standard and principles of the 'First Time Student' programmes, to ensure that the new-comers are well informed of the types of career study opportunities offered?

Part V: Developmental Programmes

17. Are there any programmes that this University or the STEM Department is currently hosting that are meant to promote the STEM fields within the University and outside?
18. Should you be requested to design a programme to improve participation of young women in the STEM fields in the Universities, which approach would you take to do that?

APPENDIX D: QUESTIONNAIRE FOR STUDENTS

QUESTIONNAIRE

THE SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS (STEM) STUDENTS

University: _____

Answer each question by marking the appropriate number in the box with an 'X'

RECORD

SECTION A: BIOGRAPHICAL INFORMATION

Gender

Male	1
Female	2
Other	3

What is your age currently?

18 – 20	1
21 -25	2
21 and older	3

In which year of study are you?

1st Year	1
2nd Year	2
3rd Year	3

4th Year 4

Answer each question by marking the appropriate number in the box with an 'X', which will also indicate the extent to which you agree/disagree with each statement. Use the following scale to indicate your answer:

1 Strongly Agree (SA)
2 Agree (A)
3 Not Sure (NS)
4 Disagree (D)
5 Strongly Disagree (SD)

SECTION B: Youth Development

1.	Socioeconomic empowerment is a prerequisite of 'Holistic/Sustainable Youth Development'	**1**	**2**	**3**	**4**	**5**
2.	South Africa, like the rest of the World is experiencing socioeconomic challenges because of climate change and security of food supply affecting the development of young people in general	**1**	**2**	**3**	**4**	**5**
3.	Girls and boys, young women and young men are equally developed through relevant programmes in South Africa	**1**	**2**	**3**	**4**	**5**
4.	The Constitution of the Republic of South Africa, Act 106 of 1996 promotes youth development and protects the rights of young people by all means	**1**	**2**	**3**	**4**	**5**

SECTION C: **Economic Empowerment and Social Transformation**

5.	Young women have more socioeconomic challenges than their male counterparts	**1**	**2**	**3**	**4**	**5**
6.	Young men are mostly actively involved in the economy of the country than young women	**1**	**2**	**3**	**4**	**5**

7.	Most young students in the Universities are aware of the skills that are said to be scares and yet critical to improve the economy of South Africa	**1**	**2**	**3**	**4**	**5**
8.	Economic empowerment is a requirement for social transformation	**1**	**2**	**3**	**4**	**5**

SECTION D: Career Choice

9.	Research shows that the STEM fields are dominated by men. Therefore, STEM fields are meant for men, not for women	**1**	**2**	**3**	**4**	**5**
10.	There are better career opportunities in the STEM fields than in the Social sector	**1**	**2**	**3**	**4**	**5**
11.	There are no women role-models in the STEM fields who can serve as mentors to young women in South Africa	**1**	**2**	**3**	**4**	**5**
12.	Considering the number of young women who are graduates but currently unemployed, South Africa is experiencing an oversupply of jobs in certain fields and an undersupply in the other fields	**1**	**2**	**3**	**4**	**5**

SECTION E: University Education

13.	Your University has a role to play in improving the participation of young women in the STEM fields	**1**	**2**	**3**	**4**	**5**
14.	Research shows that the roll of young women at Universities in general is higher than that of young men and that the number of young women is significantly low in the STEM fields because most of them register to study in the Social fields	**1**	**2**	**3**	**4**	**5**

15.	‘Tertiary education is a key factor in a nation‘s effort to develop a highly skilled workforce for competing in the global economy’	**1**	**2**	**3**	**4**	**5**
16.	The ‘First Time Student’ programme of your University informs the new-comers of the types of career opportunities offered in all the fields taught at this institution	**1**	**2**	**3**	**4**	**5**
17.	The career field which you are studying now at your University was your first career choice	**1**	**2**	**3**	**4**	**5**

SECTION F: Developmental Programmes

Answer the following questions by filling in the information asked for in the spaces provided underneath to the best of your ability:

18. What is your understanding of the concept ‘Youth Development’?

_____

_____

_____

_____

_____

_____

_____

19. What does socioeconomic empowerment entail?

_____

_____

_____

_____

_____

_____

_____

_____

20. Why did you choose a career in the STEM fields?

21. Do you know of any programmes that are introduced by Government and/or the University that are meant to promote the STEM fields?

22. Should you be requested to design a programme to improve participation of young women in the STEM fields, what would be your first five steps to do that?

23. Is there any other way/programme that may assist to improve the participation of young women in the STEM fields?

APPENDIX E – ETHICS CLEARANCE CERTIFICATE

UNISA university of south africa

COLLEGE OF EDUCATION RESEARCH ETHICS REVIEW COMMITTEE

19 October 2016

Ref : **2016/10/19/30922534/35/MC**
Student : Mrs LL Toolo
Student Number : 30922534

Dear Mrs Toolo

Decision: Approved

Researcher: Mrs LL Toolo
Tel: +2782 202 4350
Email: Linen.toolo50@gmail.com

Supervisor: Prof. MM Dichaba
College of Education
Department of ABET and Youth Development
Tel: +2712 481 2727
Email: dichamm@unisa.ac.za

Proposal: An awareness programme to improve participation of young women in the science, technology, engineering and mathematics (STEM) fields in South African Universities

Qualification: D Ed in Curriculum Studies

Thank you for the application for research ethics clearance by the College of Education Research Ethics Review Committee for the above mentioned research. Final approval is granted for the duration of the research.

The application was reviewed in compliance with the Unisa Policy on Research Ethics by the College of Education Research Ethics Review Committee on 19 October 2016.
The proposed research may now commence with the proviso that:

1) *The researcher/s will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.*
2) *Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study, as well as changes in the methodology, should be communicated in writing to the College of Education Ethics Review Committee.*
3) *An amended application could be requested if there are substantial changes from the*

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone +27 12 429 3111 Facsimile +27 12 429 4150
www.unisa.ac.za

APPENDIX F – LANGUAGE EDITING CERTIFICATE

This Certificate serves to confirm that

Dr E. M. Murray, DLitt et Phil (English) University of Johannesburg
Certificate: Editing Principles and Practices, University of Pretoria

813-26th Avenue, Rietfontein, Pretoria 0084
Freelance editor

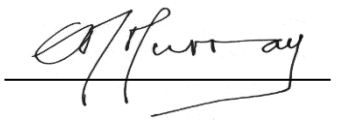
Judiciously edited a DEd thesis for submission to the University of South Africa titled:

An Awareness Programme to Improve Participation of Young Women in the Science, Technology, Engineering and Mathematics (STEM) Fields in South African Universities

Issued without prejudice to

LINEO LYNNETTE TOOLO

01 June 2018



APPENDIX G – APPROVAL FROM UFS AUTHORITIES

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA
UFS UV

UNIVERSITY OF THE FREESTATE RESEARCH ETHICS COMMITTEES

APPROVAL FROM UFS AUTHORITIES
FOR PARTICIPATION OF STUDENTS/STAFF IN RESEARCH PROJECTS

Title, Initials, Surname:	Lineo Toolo	**Staff/Student number**	30922534
Department/Institution:	UNISA (School of Education)		
Phone:	0822024350	**E-mail address:**	lineo.toolo50@gmail.com
Supervisor(s):	Prof. M.M. Dichaba	**Phone:**	012 481 2727

Protocol Title:	An awareness programme to improve participation of young women in the science, technology, engineering and mathematics (STEM) fields in South African Universities.

Who will be involved in the study? (tick ✓)	☒ UFS Personnel	☒ Students

INSTRUCTIONS:

- Please attach the following to this form when requesting approval from the signatories:
  - A short summary of the study protocol;
- Kindly note that it is the responsibility of the researcher(s) to ensure that all relevant signatures are obtained before this signed form is attached to your Ethical Clearance Application's Document Checklist on RIMS.
- Please choose either section A, B **OR** C below.
- *Please note:*
  - *If you are doing research on any students from the UFS you require the permission of the Dean: Student Affairs B (i).*
  - *If you are doing research on students/staff from a non-academic/support service division at the UFS you require the permission of the Director / Snr Director of the Division C (i).*
- Section D is **mandatory** for all research on campus.

Page 1 of 3

FORM: Approval from UFS Authorities v01
Effective date: June 2016
University of the Free State

OR

C. FOR RESEARCH ON STAFF FROM SUPPORT SERVICES:		
i. DIRECTOR / SNR DIRECTOR OF SUPPORT SERVICE DIVISION	☐ Approved	☐ Not Approved
Signature:	Date:	
Comments:		

AND

D. ALL RESEARCH ON STUDENTS AND/OR STAFF TO BE APPROVED BY:		
i. VICE-RECTOR: RESEARCH	☑ Approved	☐ Not Approved
Signature:	Date:	
CWitthuhn	29/06/2017	
Comments:		

Prof. Corli Witthuhn
Viserektor:Navorsing - Vice Rector:Research
Universiteit van die Vrystaat
University of the Free State
Hoofgebou K61 Tel. 051 - 401 2116

Die Universiteit van die Vrystaat
The University of the Free State
2017 -06- 29
Prof. R.C. Witthuhn
VISEREKTOR: NAVORSING
VICE RECTOR: RESEARCH

existing proposal, especially if those changes affect any of the study-related risks for the research participants.

3) The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study.

Note:

The reference number **2016/10/19/30922534/35/MC** should be clearly indicated on all forms of communication [e.g. Webmail, E-mail messages, letters] with the intended research participants, as well as with the College of Education RERC.

Kind regards,

Dr M Claassens
CHAIRPERSON: CEDU RERC
mcdtc@netactive.co.za

Prof VI McKay
EXECUTIVE DEAN

University of South Africa
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APPENDIX H – DHET PERMIT

higher education & training
Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

Private Bag X174, PRETORIA, 0001, 123 Francis Baard Street, PRETORIA, 0002, South Africa
Tel: (012) 312 5911, Fax: (012) 321 6770
Private Bag X9192, CAPE TOWN, 8000, 103 Plein Street, CAPE TOWN, 8001, South Africa
Tel: (021) 469 5175, Fax: (021) 461 4761

Enquiries: Mmaphake Ramasodi ***Email: Ramasodi.m@dhet.gov.za*** ***Telephone: 012 312 5345***

Ms Lineo Toolo
128 Alkalien
Zwartkop Extension 8
CENTURION
0157

By e-mail: Lineo.toolo50@gmail.com

Dear Ms Toolo

REQUEST FOR PERMISSION TO UNDERTAKE RESEARCH IN THE DEPARTMENT OF HIGHER EDUCATION AND TRAINING: IMPROVING PARTICIPATION OF YOUNG WOMEN IN THE SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS FIELDS IN SOUTH AFRICA

I acknowledge receipt of your request for permission to conduct research at the Department of Higher Education and Training (the Department) on the topic '*Improving Participation of Young Women in the Science, Technology, Engineering and Mathematics fields in South Africa'.*

The Department has evaluated your request and it is my pleasure to inform you that your request for permission to undertake the above research has been granted.

The officials you identified for the completion of a questionnaire, individual interviews and a focus group discussion at the Department are the following:

a) The Director-General; and
b) 3 Chief Directors.

You are advised to obtain further permission from the participants before commencing with your study.

You are also requested to attach the following documents when communicating with the participants.

1) Copy of this letter from the DHET.
2) Copy of the "completed application form" to undertake research.
3) Ethics clearance from University of South Africa.

The topic of your research is of great interest to the Department. It will therefore be appreciated if you could share the findings of your research with the Department upon completion of your research.

You are advised to be in contact with Ms Ramasodi to assist you with identifying the officials for your data collection.

I wish you all of the best in your research study.

Yours sincerely

Dr SNP Sishi
Deputy Director-General: Planning, Policy and Strategy
Date: 2019 / 05 / 28

APPENDIX I –ETHICAL CLEARANCE

UNISA university of south africa

RESEARCH PERMISSION SUB-COMMITTEE (RPSC) OF THE SENATE RESEARCH, INNOVATION, POSTGRADUATE DEGREES AND COMMERCIALISATION COMMITTEE (SRIPCC)

25 August 2017

Decision: Research Permission Approval from 25 August 2017 until 31 December 2017.

Ref #: 2017_RPSC_054
Ms. Lineo Toolo
Student #: 30922534
Staff #: N/A

Principal Investigator:
Ms. Lineo Toolo
Department of Curriculum Studies
School of Educational Studies
College of Education
Lineo.toolo50@gmail.com

Supervisor: Prof Mpho Dichaba
dichamm@unisa.ac.za, (012) 484-1000/ 082 841 7533

A study titled: "An awareness programme to improve participation of young women in the Science, Technology, Engineering and Mathematics (STEM) fields in South African universities."

Your application regarding permission to conduct research involving UNISA employees, students and data in respect of the above study has been received and was considered by the Research Permission Subcommittee (RPSC) of the UNISA Senate, Research, Innovation, Postgraduate Degrees and Commercialisation Committee (SRIPCC) on 24 August 2017.

It is my pleasure to inform you that permission has been granted for the study. You may:

1. Gain access to the MyLife email addresses of female students registered for Science, Technology, Engineering and Mathematics (STEM) modules through the gatekeeping assistance of your supervisor.

Open Rubric

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2. Invite two female students to participate in the interviews and send a survey to 50 female students registered for STEM modules.
3. Gain access to a list of the STEM undergraduate lecturers; their names and email addresses through the gatekeeping assistance of the supervisor, in order to invite two lecturers to participate in voluntary interviews and ask five to fill in a questionnaire.
4. The RPSC requests further clarification regarding the request pertaining to a record of students registered for Social Sciences and a record of male STEM students, before permission to gain access to these records can be granted.

You are requested to submit a report of the study to the Research Permission Subcommittee (RPSC@unisa.ac.za) within 3 months of completion of the study.

The personal information made available to the researcher(s)/gatekeeper(s) will only be used for the advancement of this research project as indicated and for the purpose as described in this permission letter. The researcher(s)/gatekeeper(s) must take all appropriate precautionary measures to protect the personal information given to him/her/them in good faith and it must not be passed on to third parties. The dissemination of research instruments through the use of electronic mail should strictly be through blind copying, so as to protect the participants' right of privacy. The researcher hereby indemnifies UNISA from any claim or action arising from or due to the researcher's breach of his/her information protection obligations.

Note:
*The reference number **2017_RPSC_054** should be clearly indicated on all forms of communication with the intended research participants and the Research Permission Subcommittee.*

We would like to wish you well in your research undertaking.

Kind regards,

Dr Retha Visagie – Acting Chairperson
Email: visagrg@unisa.ac.za, Tel: (012) 429-2478

Prof A Davis – Acting Executive Director: Research
Email: davisa@unisa.ac.za, Tel: (012) 429-8357

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