The value of STEM high school intervention programmes

by

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ABSTRACT

Hans Vestberg, the Chief Executive Officer of Verizone Communication (2018) explains that as computers become more and more intelligent, equaling human mental capacity and even surpassing it, it is essential that education move to promote and instill quality STEM skills which are required to meet the needs of a more technology-driven society. Science, Technology, Engineering and Math (STEM) skills are just not important to enter most fields of higher education but are important as the world moves towards the next industrial revolution.

With this in mind, this research discussed a STEM programme which was conducted as a Corporate Social Responsibility (CSR) learning intervention programme at two black township schools, east of Johannesburg, South Africa. This programme has run from 2016 to 2018. The primary objective of this research was to evaluate the effectiveness of the STEM intervention programme in preparing students for STEM-related studies in science and engineering disciplines at universities. The research design employed was a case study using Company X which instigated the process Company X is a globally positioned company with a presence in South Africa.

The Company X needs qualified scientists and engineers to facilitate its development in South Africa. Science and engineering skills are currently in short supply in South Africa. The methodology adopted was one-one-one qualitative interviews using semi-structured, open ended questions presented as an interview schedule. Stakeholders of the programme have been interviewed two years after the conclusion of the programme (2020) to evaluate the effectiveness of the programme in preparing the students for STEM-related studies in science and engineering disciplines at universities in 2018. Interviews were also conducted with 6 learners who participated in the STEM intervention programme while in matric. Additionally, two Principals of the respective schools as well as the programme manager of the training company (Trainer A) were interviewed in a bid to get their perceptions on the effectiveness of the programme.

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Table of contents

Abstract....iii

Acknowledgments.... iv

List of Abbreviations and Acronyms.... x

List of figures x

List of tables.... xi

CHAPTER 1 1

1.1 Introduction 1

1.1.1 Background to the Research 1

a) Scarce Skills in South Africa 2

1.1.2 Company X (A multi-national manufacturing company).... 9

1.1.3 Company X's STEM high school intervention programme 11

1.1.4 The Township X Learner Excellence Programme 14

1.2 Definition of key concepts xii

1.3 Problem statement 16

1.4 Research questions.... 17

1.3.1 Primary research question.... 17

1.3.2 Secondary questions 17

1.5 Research objectives 18

1.5.1 Primary research objective 18

1.5.2 Secondary research objectives.... 18

1.6 Review of research design adopted 18

1.7 Research method adopted 18

1.8 Limitations of the study 19
1.9 Significance of the study 19
1.10 Overview of the chapters 19
1.10.1 Chapter 1 – Introduction 19
1.10.2 Chapter 2 – Literature review 20
1.10.3 Chapter 3 – Research design and methodology 20
1.10.4 Chapter 4 – Presentation of findings and interpretation of results 20
1.10.5 Chapter 6 – Conclusions and recommendations 20
1.11 Summary 21

CHAPTER 2 22
2.1 Introduction 22
2.2 The relevance of STEM in creating Engineers 22
2.3 Shortage of STEM-related skills in South Africa 23
2.4 Science, technology and preparedness for the Fourth Industrial Revolution (4IR) 25
2.5 The role of CSR efforts by multinationals in South Africa 27
2.6 Summary 29

CHAPTER 3 31
3.1 Introduction 31
3.2 Research design 31
3.2.1 Interview schedule questions 32
3.3 Research method 35
3.3.1 Sampling 37
3.4 Data collection 39

3.5 Data analysis 41
3.5.1 Content analysis 41
3.5.2 Trustworthiness 42
a) Credibility 42
b) Transferability 42
c) Dependability 43
d) Authenticity 43
3.6 Ethics 43
3.7 Summary 43

CHAPTER 4 44
4.1 Introduction 44
4.2 Background of the participants 44
4.2.1 Profile of the student participants 44
a) Gender of the students 45
b) Age 45
c) Ethnicity 45
d) Field of study and university entrance 46
4.2.2 Profile of Trainer A: Programme Manager 46
4.2.3 Profile of Principal A 46
4.2.4 Profile of Principal B 47
4.3 Presentation of findings 47
4.3.1 Findings relating to the interviews with the students 47
a) Question 1: How often did you attend the extra STEM lessons? 47

b) Question 2: Do you believe that being on the programme gave you an advantage over other students who were not on the programme? 48

c) Question 3: In your opinion did the STEM programme contribute to your overall success in Mathematics and Science in your final matric results? 50

d) Question 4: How did the STEM programme shape your attitude towards Mathematics and Science in the 3 years that you were on the programme? 52

e) Question 5: How has being in the programme prepared you for your tertiary education in your chosen field? 54

f) Question 6: Do you believe that being in the programme influenced you choosing a career in the 'Engineering' or the 'Science' field? 56

g) Question 7: Did you meet all the requirements of the STEM programme? 57

h) Questions 8: Would you recommend the programme to other students interested in entering the Engineering or Science field? 58

4.3.2 Findings relating to the interview with Trainer A: Programme Manager 59

4.3.3 Findings relating to the interview with Principal A 69

4.3.4 Findings relating to the interview with Principal B 71

4.4 Interpretation of results 73

4.4.1 Results relating to the profile of the participants 73

4.4.2 Results relating to the value of the STEM intervention programme 74

4.4.3 Results relating to the influence of the STEM programme towards the Sciences 75

4.4.4 Results relating to challenges faced while on the STEM intervention programme 75

4.4.5 Results relating to the outcome of the STEM intervention programme 76

4.5 Summary 77

CHAPTER 5 79

5.1 Introduction 79

5.2 Conclusions 79
5.2.1 Conclusion relating to the primary research objective 80
5.2.2 Conclusions relating to secondary research objectives 82
a) Conclusion relating to secondary research objective 1 83
b) Conclusion relating to secondary research objective 2: 83
c) Conclusion relating to research objective 3: 84
d) Conclusion relating to secondary research objective 4: 85
5.3 Recommendations relating to findings of the study 85
a) Recommendations for STEM intervention programme implementation strategies 85
b) Recommendations for future study 86
6.1 Summary 87
Appendix 1 88
Appendix 2 89
References 92

LIST OF ABBREVIATIONS AND ACRONYMS

Abbreviation	Meaning
AA	Affirmative Action
BBBEE	Broad-Based Black Economic Empowerment
CSR	Corporate Social Responsibility
DBE	Department of Basic Education
DHET	Department of Higher Education and Training
DTI	Department of Trade and Industry
DoL	Department of Labour
FET	Further Education and Training
GET	General Education and Training
4IR	Fourth Industrial Revolution
HSRC	Human Sciences Research Council
IT	Information Technology
JSE	Johannesburg Stock Exchange
MNE	Multinational Enterprises
OIHD	Occupations in High Demand
PDI	Previously Disadvantaged Individuals
SACSIS	South African Civil Society Information Service
STEM	Science, Technology, Engineering and Mathematics
SRI	Socially Responsive Index
TVET	Technical and Vocational Education and Training
US	United States
USA	United States of America

LIST OF FIGURES

Figure 1.1: Generic Balanced Scorecard Example

Figure 3.1: Methodological choice

Figure 4.1: Gender distribution of interviewed students

Figure 5.1: Gender distribution for all participants

Figure 5.2: 2018 Programme participants' matric results

LIST OF TABLES

Table 1.1: Top 10 jobs which employers are having difficulty filling

Table 3.1: Interview schedule questions

Table 3.2: Participants of the research

Table 3.3 Biographic details of the participants

Table 4.1: How often did you attend the extra STEM lessons?

Table 4.2: Do you believe that being on the programme gave you an advantage over other students who were not on the programme?

Table 4.3: In your opinion did the STEM programme contribute to your overall success in Mathematics and Science in your final matric results?

Table 4.4: How did the STEM programme shape your attitude towards Mathematics and Science in the 3 years that you were in the programme?

Table 4.5: How has being in the programme prepared you for your tertiary education in your chosen field?

Table 4.6: Do you believe that being in the programme influenced you choosing a career in the 'Engineering' or the 'Science' field?

Table 4.7: Did you meet all the requirements of the STEM programme?

Table 4.8: Would you recommend the programme to other students interested in entering the Engineering or Science field?

Table 4.9: Presentation of findings from the interviews with the Trainer A: Programme Manager

Table 4.10: Trainer A's Top Learners 2018

Table 4.11: Result Analysis from 2016-2018

Table 4.12: Findings relating to the interviews with Principal A: the Headmistress

Table 4.13: Findings relating to the interview with Principal B: the Headmaster

DEFINITION OF KEY CONCEPTS

Scarce Skills

DHET (2018:2) describes scarce skills as job types for which employers cannot find suitably qualified or experienced employees. The department further elaborates that these are occupations which are in high demand. However, there is a shortage with regards to the supply in the labour market.

Previously Disadvantaged Individuals (PDIs)

According to the National Empowerment Fund (Nerfcorp, 2005:1), the term Previously Disadvantaged Individuals refers to those people or categories of persons who, prior to the new democratic dispensation, were disadvantaged by unfair discrimination on the basis of their race and includes juristic persons or association owned or controlled by such persons.

1.1 INTRODUCTION

This study evaluated the effectiveness of a Science, Technology, Engineering and Mathematics (STEM) high school programme in preparing students for STEM-related studies in science and engineering disciplines in universities. The STEM programme that this study employed as in its case study is the one sponsored as a Corporate Social Responsibility (CSR) initiative by a multi-national company with headquarters in the United States of America (USA). For the purpose of this research, and in line with ethical considerations, namely the assurance of the participants' confidentiality and anonymity, this particular company will be referred to as Company X. Confronted with scarcity of qualified engineering skills while based in the host country of South Africa, Company X decided to introduce STEM intervention programme in the form of STEM-related supplementary classes to two high schools in a previously disadvantaged black township, east of Johannesburg. For the purpose of this study, this township will be referred to Township X in line with ethical considerations that guarantee confidentiality and anonymity to research participants.

This research evaluates the effectiveness of the STEM high school intervention programme in preparing students from previously disadvantaged backgrounds to further their education in STEM-related studies in science and engineering disciplines in universities. This chapter lays out the background of the research, objectives of the research and also describes the arrangement of the chapters in this research study.

1.1.1 Background to the Research

This research looks at a corporate social responsibility initiative by Company X in an effort to improve the final year pass marks for students from two underprivileged high schools in

Johannesburg. The research examines extra lessons that took place over a period of 3 years for a group of 20 learners focusing on Math, Science and English.

a) Scarce Skills in South Africa

Previously Disadvantaged Individuals (PDI) in post-apartheid South Africa are those groups that where marginalised from economic activity during the apartheid era (Daniels, 2007). "The accumulation process under Apartheid confined the creation of wealth to a racial minority and imposed underdevelopment on black communities. The result is an economic structure that today still excludes the vast majority of South Africans" (Irene, 2017:147). Black people are defined in the Broad-Based Black Economic Empowerment Amendment Act, 2013 (Act No. 53 of 2003), as a generic term which means Africans, Coloureds, Chinese and Indians. The marginalisation by race caused many black Africans not to have the opportunities to undertake training in engineering. This has resulted in black African engineers being considered as a scarce human capital resource in South Africa as so few have qualified some twenty years after apartheid concluded in 1994.

Rasool and Botha (2011) point out that skills shortage in South Africa is as a result of a combination of several complex socio-political and economic factors. They elucidate that the current government inherited a divided education system that was established by the apartheid government, which comprised of fifteen departments divided along racial and regional lines. This has resulted in a shortage of skills within certain racial groupings. Mateu et al (2014) refers to a report by the Solidarity Research Institute (Solidarity Research Institution, 2008:2) which indicated "that 81% of South African companies struggle to find appropriate staff, with 76% having difficulty finding employment equity candidates, in particular.

According to the Solidarity Research Institute, the evidence lies in the particular shortage of chartered accountants, IT specialists, sales and marketing personnel, and scientists. Solidarity Research Institution (2008) also claims that both the South Africa Institute of Architects and the Institute of Draughting are also experiencing a shortage of skilled professionals. In 2011, figures released by Adcorp showed over eighty-two thousand unoccupied positions in high-skilled occupations in South Africa (Polity.org). As Solidarity Research Institution (2008) indicated, the Human Sciences Research Council (HSRC) found that there is a shortage of between 350 000

and 500 000 qualified people to fill managerial and technical positions (Solidarity Research Institution, 2008:5)". Ramotloua (2016) describes scarce skills as those job types for which employers cannot find suitably qualified or experienced employees.

The Department of Labour (DoL, 2006) refers to scarce skills as an absolute or relative demand of skilled people to fill particular roles/ professions or occupations in the labour market. In 2018 the Department of Higher Education and Training in an effort for education to be better coordinated with the economic needs of the public and private sector, in the Government Gazette identified Occupations in High Demand (OIHD). According to the Department of Higher Education and Training (DHET) Government Gazette (2018:8), OIHD are those that show relatively strong employment growth and are experiencing shortage in the labour market or are expected to be in demand in the future. They have come up with a list of OIHD jobs which will be updated every two years, the level of demand on the list range from Highest to High level of demand, different types of Engineering disciplines sit on the highest level of demand such as mechanical, aeronautical, chemical, civil and industrial engineering.

"Total graduations across all engineering disciplines between 1998 and 2010 numbered 70,475, at 13.8% pass rate. Of this total 29,280 engineers graduated with degrees from universities, which is an average of 2,252 per year. While there was an upward trend for black and female engineering graduates, the average university pass rate of all engineering students was 16%, far below the international level of 25%" (Schutte, Kennon & Bam, 2016:7). Schutte et.al (2016) observe that the challenge that South Africa faces with regards to engineering skills do solely rest with the tertiary institutions but need the secondary schooling system to develop capabilities throughout the schooling system.

In an effort to redress the inequalities of the past and build an equitable society, the South African Government has introduced Broad Based Black Economic Empowerment (BBBEE). Irene (2017) explains that the South African Department of Trade and Industry (DTI) growth strategy includes broadening participation, equity and access for those who were previously disadvantaged and marginalised. Organisations are expected to manage a balanced scorecard concept in the organisation that encourages training and learning; Irene (2017) further expands that a score card can act like a measure for economic empowerment of all black people. One of

the main objectives of BBBEE is to increase the participation of all black people in business. Irene also notes that the balanced score card can influence the increase in the rate of black men and women-owned businesses and increasing the number of all the black population in the management structure of existing and new initiatives as well as increased access to financial and human resources. The balanced scorecard has five pillars:

- **Ownership** which pertains to the ownership of the company, how much of the ownership is black and what are their voting rights. According to the DTI Government Gazette (DTI, 2018) this increases the number of black people who control and own enterprises and assets.

- **Management Control** looks at the percentage of black senior managers and the composition of the board, with an aim of increasing the numbers of black people in managerial positions. Arya and Bassi (2011) explain that this measures the initiatives intended to achieve equity in the workplace; they expand further that this pillar seeks to promote participation of historically disadvantaged people in business management. This includes encouraging representation of black people on company boards as part of executive and non-executive management.

- **Skills Development** focuses on the investment made by the company to the skills development of its black workforce through bursaries and learnerships. According to Arya and Bassi (2011), this pillar measures the extent to which employers have in place initiatives to develop the competencies of black employees in the workplace.

- **Enterprise Development,** according to Arya and Bassi (2011), encourages large corporates to use and develop small black companies in its operations.

- **Social Economic Development** "refers the extent to which the organisation is involved in Social Investment Initiatives. It seeks to promote corporate initiatives contributing to socioeconomic development. The fundamental principle of this code is to encourage public programs by organizations that further socioeconomic development in South Africa" (Arya & Bassi, 2011:684)

Large businesses, such as Company X, are not forced to comply with the above pillars. However, they are incentivised to comply. The Department of Trade and Industry in the Government Gazette no 36928 (2018) states that the Codes of Good Practice apply to all measured entities which undertake business with either organs of state or public entities who are forced to comply with the BBBEE regulations. Company X has a big contract with one of the State-Owned Enterprises (SOE) and is therefore required to be compliant at a level 3, which means that it has to get between 90 to 100 points in order to retain its contracts and continue getting government contracts. Figure 1.1 refers to a generic scorecard.

Figure 1.1: Generic Balanced Scorecard Example

BBBEE Element	Maximum Number of Weighting Points Available
Ownership	25
Management Control	15 plus 4 bonus points
Skills Development	20 plus 5 bonus points
New Enterprise and Supplier Development	40 plus 4 bonus points
Socio-Economic Development	5
TOTAL	118

Source: Werkmans (2020)

Arya and Bassi (2011) state that through the deployment of the Broad-Based Black Economic Empowerment (BBBEE) the government has sought to involve corporations in addressing problems of historical exclusion of black people from the mainstream economy. Arya and Bassi (2011) further illustrate that the Department of Trade and Industry's implementation of the recommended codes of conduct in encouraging and managing organisational diversity was also meant to ensure that there is consistency in the implementation of socially responsible behaviour and the empowerment of historically disadvantaged black people within the organisations across industries.

The term relative scarcity is applicable in this research and refers to an instance (a) where black engineers are available but do not meet the employment criteria i.e. this research focuses *on*

scarcity within a certain group, or a situation (b) where suitably skilled people exist, but do not meet other employment criteria, for example they live in different geographical areas, or do not satisfy Black Economic Empowerment criteria" (Daniels, 2007:2). In this case, relative scarcity relates to racial groupings. The Department of Labour (DoL) explains this concept under equity considerations, expanding that this is when there are few, if any, candidates with the required skills from a specific group. For the purpose of this research, this definition of relative scarcity as explained above refers to the African black racial group, available to meet the skills required by the market (DoL website). Mzangwa (2017) refers to Affirmative Action (AA) as a policy that is meant to actively decolonise the principles that sought to exclude black people from the good labour market jobs.

DHET (2018) defines Occupations in High Demand (OIHD) as those jobs that have shown relative strong growth in the recent years; are expected to show strong growth in the future; have been shown to be in short supply in the labour market or are expected to emerge in the future as a result of technology and innovation. Reddy et al. (2018) explains that the OIHD's list of Occupations in High Demand replaces the DoL's list of scarce skills. The DHET has divided the list into three categories; highest demand, higher demand and high demand. The list compiled by the DHET has more than 350 jobs, engineering is categorised under highest. The annual ManPower Talent Shortage Survey (2018) details a list of top 10 jobs which employers are finding difficult filing in South Africa: Engineering professionals feature third on the list of in-high-demand jobs in South Africa. As a human resources practitioner, the researchers shares the sentiment that it has become exceedingly difficult to find the right skills in a market that is becoming smaller with globalisation, where everyone is fishing from the same pool.

The ManPower Talent Shortage report (2018) shows a global list of high in-demand jobs; as compared to the South African list, this report shows engineering as the fourth highest in demand globally. The list comparing the South African and the global skills in demand proves that the world is looking for the same skills sets from the market. The report points out that "companies are also trying to reach new talent pools and attract more people on the margins into the workforce. 33% are looking at different demographics, age ranges or geography."

The Table 1.1 below shows the top 10 jobs which employers are having difficulty filling.

Table 1.1: Top 10 jobs which employers are having difficulty filling

Globally	South Africa
1. **Skilled Traders (electricians, carpenters, welders, bricklayers, plasterers, plumbers)**	Skilled Traders (electricians, carpenters, welders, bricklayers, plasterers, plumbers)
2. **IT Staff (developers, programmers, database admin, IT Leaders and Managers)**	Management (Executives, senior board -level managers)
3. **Sales Representatives (Sales executives, sales advisors and retail sales**	Office Support Staff (secretaries, personal assistance, receptionist, admin assistance)
4. **Engineers (managers, electrical, civil engineers)**	Engineers (managers, electrical, civil engineers)
5. **Technicians (production operators or maintenance technicians)**	Accounting, finance staff (bookkeepers, certified Accountants, financial analysts)
6. **Drivers (trucks, lorry, heavy goods,)**	Sales Representatives (Sales executives, sales advisors and retail sales
7. **Accounting and Finance**	Technicians (production operators or maintenance technicians)
8. **Management (Executives, senior board -level managers)**	Drivers (trucks, lorry, heavy goods,)
9. **Production Operators**	Teachers
10. **Office Support Staff (secretaries, personal assistance, receptionist, admin assistance)**	IT Staff (developers, programmers, database admin, IT Leaders and Managers)

Source: Manpower Group (2020)

Organisations have been encouraged to adjust their recruitment strategy in search of talented black South Africans to take up high ranking positions. According to Juggernath, Rampsersad and Reddy (2011), the impact of the BBBEE Act is to increase the participation of black people and to create access to resources, infrastructure and training.

“Previous business research has highlighted the impact of government policy in the process of formulating business strategies and in the decision-making process of organisations. In the South African context, a review of this impact on organisational strategy is important especially after the fall of apartheid as businesses have been obligated to manage widespread institutional change the purpose of which is to redress historic inequalities that characterised the apartheid regime. Specifically, the government monitors the introduction of the far-reaching BBBEE policy aimed at increasing participation of PDIs in economic activities” (Irene, 2017:147).

The implementation of BBBEE can be impeded by the lack of qualified skills in the market. Muller (2018) explains that engineering has been coloured by colonial/ apartheid objectives which determined who came into the engineering profession and, equally important, who was excluded from the profession as a consequence, leading to scarcity of black professionals in engineering. Breier (2009) notes that due to the under-funded and poor-quality education of the black community during apartheid, there is still a limited number of matriculants who have the necessary high school grades and financial resources to access programmes like engineering at tertiary level.

Kock and Burke (2008) note that although the country’s economy is growing, the country lacks sufficient numbers of skilled professionals and that, for the previously disadvantaged, even the quality of education has not changed. According to Kock and Burke (2008), the misalignment between the needs of the growing economy and the ability of the education and training system to provide the necessary quantity and quality of skilled workers put an extra demand on companies to attract and retain skilled human capital. Fischer and Scott (2011) explain that higher education (colleges and universities) has a unique role to play in resolving the skills shortage in South Africa. This can be attained by producing graduates who will importantly lead the country’s future research and innovation. Mdepa and Tshiwula (2012) state that, in order to overcome the legacy of legalised exclusion of the majority of the population from educational

and economic opportunities, the country has no choice but to redress issues related to inclusion of diversity in higher education.

According to Fisher and Scott (2011), raising education and skills levels is crucial not only for an increased workforce, but also for enhancing the innovative capacity of the economy and facilitating the absorption and diffusion of innovative technology. Bearing in mind the need for South Africa to create opportunities for young black engineers to enter the engineering industry, this study also focuses on the efforts of a global manufacturing organisation, referred to as Company X in this research, in recruiting engineers for its success internationally. As part of its CSR, Company X took a decision to identify South African high school learners studying Mathematics and Science and support them through three (3) years of lessons at school in preparation to gain university entry. This was also seen as a way to build a pipeline of skills for Company X through continuous financial support and internship opportunities. Ricardo (2015) describes the value of having internships at a company, noting that an intern is a cost-effective resource that can provide a fresh perspective in projects. Internships can also be a valuable career experience for the intern or student and, most importantly, these students can be used to create a skills development pool for future recruitment in that particular industry. Ricardo (2015) further explains that internships provide an opportunity for students to learn activities vital to their educational and career goals; they also provide the students with valuable work experience before graduating.

In the next section, the researcher provides a brief description of Company X as the study's chosen case study organisation.

1.1.2 Company X (A multi-national manufacturing company)

Company X is one of the United States of America's biggest multi-national companies operating in more than 160 countries worldwide. It is one of the oldest American companies founded in 1892, with over 305 000 employees worldwide and a revenue of no less than $147.35 billion US dollars. "Fortune magazine announced on March 5th, 2007 that Company X tops its 25th annual list of America's Most Admired Companies, the second consecutive year the Fairfield, based conglomerate has topped the list. Company X is one of only two

companies, along with Johnson & Johnson, who were on Fortune's first ever most admired list and appeared in the top 10, 25 years later" (RP news, 2007:1).

In 2017 Company X was voted number 7 in the top 10 of the Most Admired Companies by Fortune Magazine. The company is an Industrial Machinery Manufacturer that operates in eight (8) different industries, such as: (a) Aviation, as one of the world's leading manufacturer of large jet aircrafts; (b) Healthcare, inventing some the world's cutting-edge technology in medical diagnostics equipment; (c) Oil and Gas, delivering technology across the energy value chain from oil ground reservoir to oil refinery; (d) Transportation, giving the world eco-friendly locomotives of a digital age; (e) Power, giving power to the world by providing innovation to build power stations, and clean renewable energy; and (f) the Capital business, which is the financial arm that assists countries to fund some of their major projects.

The company has been expanding globally in the past 10 years; in Africa Company X grew from having 6 sites in 2010 to more than double in 2015 to 25 sites. During the same period the number of employees grew from 800 to 2200, and the orders grew from $1,7 billion US dollars to $3.5 billion US dollars. Africa has been identified as the emerging market with abundant opportunities to explore. Mwanma (2018) quotes Company X Africa's CEO as saying that the company's sub-Saharan African operations employed more than 2600 employees, and has earned revenues in excess of $3.7 billion US dollars in 2017 in 25 countries in Africa, with special efforts in Nigeria, South Africa, Angola, Ghana, Mozambique and Kenya.

The company has made history with several firsts in the history of inventions, such as manufacturing the first light bulb, following this up by building the first electric grid in 1882 on Pearl Street in New York. Company X continues to bring power to South Africa through its Steam Power Systems, working with Eskom in the Medupi Power Station since 2007 to build the "fourth biggest coal-fired power plant in the world and the largest in the world" (Killian, 2017:1). This project, which was supposed to be completed in 2020, has demanded elevated levels of engineering skills to deliver for the customer on time and within budget. Company X is also involved in the construction of the Kusile Power Plant, which will consist of 6

turnkey units delivering 800MW each for a total of 4,800MW. This power will meet the needs of more than 3,5 million South Africans.

“More than 3,300 Company X professionals - direct employees and subcontractors -are working every day onsite at the Kusile Power Plant in order to ensure its timely construction and delivery. Company X has trained and qualified over 850 trade professionals and funded students. It has spent more than 18 billion ZAR on local content for both the Medupi and Kusile projects. The company X is committed to developing local skills, including investing in a site-based welding training centre to provide workplace exposure and providing bursaries for over 130 tertiary students originally from Mpumalanga Province. 80% of these bursaries were awarded for technical studies (engineering) and 20% were allocated for other disciplines, i.e. finance and IT” (Company X’s website). With these and many other projects in South Africa and Africa, Company X has a need for engineering skills in the country to successfully bid and deliver on these big projects. The student success rate is approximately 85% at various institutions within South Africa.

In 2017, Company X invested $70 million in US dollars into a Customer Innovation Center for skills development in South Africa, as well as $19 million into supplier development funds to provide financial and technical support for emerging local businesses. As the world moves into the 4th Industrial Revolution (4IR) and technology defines our everyday existence, this digital industrial company understands the need for strong technical talent to continue to grow in the region.

Being an innovator and trend-setter, it is important that the company recruits the best talent in the market to carry on this tradition of creating things that change lives. Engineering skills are of outmost importance to Company X and, as it expands its footprint in the region, the need for strong, qualified and skilled engineering talent also increases.

1.1.3 Company X’s STEM high school intervention programme

Operating in South Africa, Company X is known for developing and nurturing talent through their early career identification programmes. Globally, the company runs nine development programmes for new graduates, the oldest being the Engineering Development Programme. “This program accelerates professional and technical development within Company X’s advanced courses in Engineering and a variety of business-critical engineering assignments” (Company X, April 2020). In South Africa Company X has, as part of Corporate Social Responsibility, decided to start the Company X Excellence Programme to encourage students in high school to take up and study STEM-related subjects.

In June 2016 Company X extended its investment in future engineers programme to two (2) high schools in the local disadvantaged community in Johannesburg. As a STEM high school intervention programme, this initiative was designed to encourage students to select technical subjects, such as mathematics and science, for matriculation which would enable them to get university entrance for engineering and other science-related degrees. An article in BusinessTech (2018) states that the two key subjects for any engineering or IT related degree are Mathematics and Science with Mathematics requiring a minimum of 80% pass at matriculation to secure entry into the university level engineering field.

Schutte et al. (2016) highlight research done by the recruitment company Landelhani Amrop SA, in which the company highlighted that “of the 600 000 candidates who wrote matric in 2009, only 22% passed math higher grade and only 7% passed physical science higher grade. In the same year, only 28% of the students in public higher education institutions were enrolled for programmes in science, engineering and technology”. It was for this reason that Company X made the decision that STEM intervention programme should be at school level because by the time university recruitment begins, it is too late to influence the outcomes and the numbers of students studying in the STEM-related fields. Rasool and Botha (2011) observe that the poor results for Mathematics and Science are largely due to the poor quality of schooling for black learners, who then avoid pursuing careers in the fields of Science and Technology.

“Furthermore, a large number remain marginalised because they lack the specialised skills the economic turnaround requires. A university study found that nearly 50% of all dropouts aged between 18 and 20 were Black first-year students (Ray, 2009:1). The Education Series volume

three of the Educational enrollment and achievement report by Statistics South Africa (2017) reveal that the African black population still lags behind in the attainment of higher-level qualifications, despite all the interventions by the government. Only 9% of African blacks have some form of higher-level educations compared with other race groups. The report further explains that 15% of African blacks drop out of school after reaching primary education and 55,3% of them are females as compared to their male counterparts. The report further highlights the shortages in the fields of Engineering, Medical Science and Finance. To assist students to bridge these two gaps and succeed as engineers, a decision was made by Company X to invite a third party to facilitate the engineer preparation process, by employing a STEM (Science, Engineering, Technology and Mathematics) Intervention Programme. “In areas where the state fails to provide collective services, external actors may step up and fill the gap” (Honke & Thauer, 2014:1).

The identified learner is then funded through their entire university undergraduate degree with tuition fees, books, meals and the necessary stationery. The students then also have the opportunity of serving internship during their school vacation at Company X. “Students benefit from preparation and scaffolding on professional activities, including internships. Whether you provided instructions on how to use LinkedIn effectively or explain how to request an informational interview, students benefit from explicit instruction” (Packard, 2018:83).

The STEM high school intervention programme is implemented for Company X by a third-party service provider, specifically employed to increase the number of high school learners succeeding in getting the university entrance with the required high school results in Mathematics, Science and English. “The education system in South Africa is characterised by low education standards, inadequate provision for early childhood development, declining Grade 12 pass rates, declining enrolments at Further Education and Training (FET) colleges, lack of resources, under-qualified teachers, weak management and poor teacher morale. High failure rates in schools, colleges and universities offer little hope of addressing the skills shortages. According to the South African Civil Society Information Service (SACSIS), these developments are obstacles to the production of skills the economy requires (SACSIS, 2009)” (Rasool & Botha; 2011:9:1).

Using the service provider to deliver the STEM intervention programme along with career guidance, students who had chosen Maths core and Science after grade 10 were selected to attend Saturday extra classes, focusing on Maths, Science and English training. Rasool & Botha (2011) explain that, despite large sums of money invested in education by the government, the results were not encouraging. According to the Educational Series Volume Three, Statistics South Africa report of 2016, the quality of education in mostly historically deprived areas remains poor, with less than adequate basic learning infrastructure. The schools do not have libraries, laboratories, internet connection and the teachers are less qualified, according to the StatsSA report. The report further state that as a result of the poor education system in these areas, the learners experience learning deprivation, high grade repetition and high dropout rates. Rasool and Botha (2011) report that South Africa came last in the global studies on literacy and reading, as well as on Mathematics and Science.

Company X has made a decision to finance students who successfully matriculated with Mathematics, Science and English to study Engineering and Science-related studies at universities in South Africa. Subsequently, these students form part of Company X's early career development programme in its effort to increase the number of learners succeeding in Mathematics, Physical Science and English from previously disadvantaged backgrounds. "The project is funded by Company X and delivered by the third-party service provider; the project started with 20 grade 10 learners in June 2016" (Netsharotha; 2018:4).

1.1.4 The Township X Learner Excellence Programme

The STEM training company Trainer A was approached by Company X to be the third-party service provider to facilitate the supplementary classes for the students of High School A as well as the students of High School B in Township X. This pilot programme, named by Company X as the Township X Learner Excellence Programme, was designed to focus on three high school subjects to improve learner matric passes; Mathematics, Physical Science and English for students through grades 10 to grade 12. In a report prepared by Netsharotha (2018:4), Project Manager at the third-party service provider outlines the main objectives of the STEM intervention programme are as follows:

- To increase the number of learners succeeding in Mathematics, Physical Science and English as well as positively affecting their attitude towards Science, Engineering and Technology;
- To supplement Mathematics, Physical Science and English learner support materials through the project;
- To improve learner's performance in Mathematics, Physical Science and English to at least 62,5% in grade 11 and 72% in grade 12 [by the end of each year]; and
- To improve (Mathematics, Physical Science and English) results in both participating schools.

Roseler, Paul, Felton and Theisen (2018) states that their research findings support elevated learning results for students who are exposed and engage in active science learning such as is provided by Trainer A. The STEM intervention programme was continuously monitored by various important stakeholders including Company X, the Principals of both schools, the East Rand Department of Education District Officer, students' parents, and a dedicated project manager. It was important to involve the area's education district officer in the project, as stated by Honke and Thauer (2015) because any attempts by multinational enterprises to effectively contribute to service provision must be seen as legitimate in the eyes of the recipient country (in this case South Africa).

The activities for the high school project delivered by Trainer A after consultation with Company X consisted of the following:

- Saturday Classes: students attended an hour and a half of tutoring per subject (English, Maths and Science). "The content covered targeted the gaps identified in the baseline test, and ensured that the learners are empowered to progress towards greater levels of excellence" (Netsharotha, 2018:6)
- Vacation Classes held during the vacation period to cover more content over the longer days during the vacation time;
- Parents meetings and involvement whereby parents were invited at the inception of the project in 2020. The parents' commitment was just as important as the learners' commitment to the project. Parents were kept up to date on the progress through the

parents' meetings. In these meetings "progress reports are shared with the parents, including the year plan and code of conduct" (Netsharotha, 2018:5);

- Management and Committee meetings: "this was [meant] to provide progress report against all measurable deliverables. The meetings were attended by Project officials, Company X, the two school principals and the Department of Basic Education (DBE) representative" (Netsharotha, 2018:7);
- Teaching and Learning resources: stationery was provided for the learners in the programme;
- Vacation Camps: "[This was a life skills camp which sought to prepare the learners for STEM careers" (Netsharotha, 2018:5);
- A life skills and career guidance programme: This was facilitated by another company for the students "in an attempt to channel and prepare the students for their future careers, while dealing with the challenges from their backgrounds" (Ngoepe, 2018:9); and
- Tutor training workshops.

When the Company X programme was initiated in June 2016, 20 students were selected for the programme, 10 from each school. Sixty-five per cent of the programme participants were female. Statistics South Africa's Statistical release (2017) state that, black African women are more vulnerable in the labour market. The report shows that black African women occupy the lower skilled occupations at 43% in Q4 2016 at lower jobs compared to white women who are more likely to be employed in skilled positions.

This research evaluates the effectiveness of this programme for two years by examining the results of the programme at the end of 2018. The matric results of the students who were in the programme were considered together with the feedback from Trainer A to determine whether the programme was a success or not in elevating the marks for the students to qualify for Engineering and Science courses in higher education institutions.

1.2 PROBLEM STATEMENT

Company X is facing challenges in recruiting high-quality engineering students from previously disadvantaged backgrounds to keep up with the company's policy of retaining its top world and

African rankings, especially in light of the disruptions in the engineering and science fields in which Company X deals extensively by technology change. The company faces constant challenges in recruiting high performing 2nd year engineering students into its pipeline engineer development programme. There is a small pool of suitable students due to inadequate preparation in high schools in the relevant subjects, i.e. not enough high school students were gaining entry to university engineering degrees and this limited the number of university students Company X can recruit. This research seeks to explore to what extent the STEM intervention programme at high school has helped Company X to identify the right youth to encourage towards engineering or related fields.

1.3 RESEARCH QUESTIONS

The aim of this research was to evaluate the effectiveness of Company X's STEM high school intervention programme by interviewing the students who participated and stakeholders who were involved in this particular programme since its inception in 2016. The above aim, lead to the researcher asking the following imperative research questions:

1.3.1 Primary research question

The primary research question for this study is:
How effective are STEM intervention programmes in preparing high school students for STEM-related studies in engineering and science disciplines at universities?

1.3.2 Secondary questions

The secondary research questions for this study are:

- What is a STEM intervention programme?
- What are possible challenges that relate to the implementation of STEM intervention programme in high schools?
- What are the strategies that can be used to effectively implement STEM intervention programmes in high schools?

- What are possible areas for future research relating the topic of effectiveness of STEM intervention programmes in high schools?

1.4 RESEARCH OBJECTIVES

The research objectives for this study are stated below.

1.4.1 Primary research objective

The primary research objective of this study is:

To evaluate the effectiveness of STEM intervention programme in preparing high school students for STEM-related studies in engineering and science disciplines at universities.

1.4.2 Secondary research objectives

The secondary research objectives arising from secondary questions of this study are:

- To clarify the concept of STEM intervention programme;
- To determine possible challenges relating to the implementation of STEM intervention programmes in high schools;
- To determine the relevance of STEM programme in creating engineers and scientists;
- To propose recommendations for future research and the strategies for successfully implementing STEM intervention programmes in high schools.

1.5 REVIEW OF RESEARCH DESIGN ADOPTED

This next section explains the research design that has been adopted for this study and also provides an outline of the rest of the study.

1.6 RESEARCH METHOD ADOPTED

The researcher adopted an interpretivist stance in this research, seeking rich information from purposefully selected stakeholders of the training programme. Ethics clearance for this research was obtained (see Appendix A). The interview schedule questions were derived from the literature review undertaken (chapter 2) and was included as appendix 2. A qualitative methodology of one-on-one interviews was employed to probe for responses from participants. Content analysis was used to analyse the transcribed interviews.

1.7 LIMITATIONS OF THE STUDY

The limitations of this study are:

- The study is a case study, so the results are only applicable to interpreting the value of training environment created by Company X; and
- The inability to interview all the black African learners in lower grades at high schools participating in Company X's STEM programme unless they are 18 years old or older.

1.8 SIGNIFICANCE OF THE STUDY

This study is significant in that it will add to an existing body of literature on implementation and the effectiveness of STEM intervention programmes in Gauteng high schools. The results of this study are also likely to be generalisable to other South African and African high schools where the STEM intervention programme is applied or considered. These results will make students aware of possible benefits that their participation in STEM intervention programmes will provide.

1.9 OVERVIEW OF THE CHAPTERS

This section provides an overview of each of the chapters and its contents.

1.9.1 Chapter 1 – Introduction

The first chapter provides a background to the research and introduces the key concepts of the research. It also gives context on scarce skills in South Africa and the STEM programme in relation to fulfilling Company X's needs for engineers and scientists as an intervention for high schools. This chapter states the research questions and objectives relating to this study.

1.9.2 Chapter 2 – Literature review

The second chapter reviews the extant literature with regards to the concept of educational interventions, specifically the STEM as an intervention programme in high schools. The effectiveness of such programmes is reviewed from a South African and global perspective. The chapter looks at the challenges in the South African public education system leading to the need for interventions like that of Company X aimed at encouraging high pass rates for high school students in technically based subjects. The role of CSR interventions by multinational companies in South Africa is also examined.

1.9.3 Chapter 3 – Research design and methodology

This chapter outlines the research design and methodology chosen for this research and the rationale behind choosing it.

1.9.4 Chapter 4 – Presentation of findings and interpretation of results

The findings are discussed in this chapter in light of previous research undertaken (reviewed in chapter 2) as well as the empirical study conducted by means of interviews. In the same chapter the researcher discusses her interpretation of the results of the empirical study that has been conducted in the form of interviews with different participants of the study.

1.9.5 Chapter 6 – Conclusions and recommendations

The last chapter concludes the research by providing a summary of this study in relation to the effectiveness of Company X's STEM intervention programme. Recommendations for the future

study and effective implementation of the STEM intervention programmes are laid out in this chapter.

1.10 SUMMARY

As the name indicates, this chapter served as an introduction to the study discussed in this document. The chapter has provided the background to the research. It discussed the key concepts relating to the STEM high school intervention programme. The research aim, objectives and questions have also been outlined in this part of study.

2.1 INTRODUCTION

This chapter provides a review of the literature on the effectiveness of STEM intervention programme in South African educational system and globally. The literature discusses the relevance of STEM in creating engineers. Along with the benefits of STEM intervention programmes, the challenges that result from the shortage of STEM-related skills in South Africa are discussed as well as the role that these skills can play in dealing with the effects of the 4th Industrial Revolution. Lastly, the role of companies' Corporate Social Responsibility is discussed with reference to the introduction and implementation of the STEM intervention programmes.

Academic books and research articles (chapters 1 and 2) were used to support and provide descriptive and theoretical foundation on the concepts. Ravitch and Carl (2016) explain that the literature review provides the conceptual overview that orients the reader and brings together the various empirical studies, concepts and frameworks presented by the researcher.

2.2 THE RELEVANCE OF STEM IN CREATING ENGINEERS

The concept of 'scarce skills', such in South African engineering field, has already had a far-reaching influence on the South African legislation and government policy, including the Skills Development Act, 1998; the National Skills Development Strategy; National Skills Fund; the DHET White Paper on Post-School Education and Training; the National Development Plan 2030; the establishment of new departments, authorities and councils (the Department of Higher Education and Training; Technical and Vocational Education and Training (TVET) Colleges; Sector Education and Training Authorities; Human Resource Development Council); and on DHET research initiatives and funding" (Balwanz et al., 2016:32). The promotion of STEM intervention programmes by the South African government as well as Company X is based on

the belief that STEM is a path to solving skills scarcity in the job market. “Government panels, business groups and educators have sounded the alarm about the state of training in science, technology, engineering and mathematics. They have concluded that STEM serves as a gateway to higher paying jobs and is an important linchpin to a growing economy” (Sawchuk, 2018:4).

The growth in demand for STEM-related careers has led to a scarcity of these skills as global companies compete to attract these skills to their own market. The result is that companies must look outside their borders for qualified and skilled people to fill these positions. According to Oosthuizen and Nienaber (2010), skills shortage in Science, Technology, Engineering and Maths has received heightened attention as ‘scarce skills’ from the South African government, thereby driving global companies to support different initiatives such high school and university interventions. However, as organisations struggle to meet BBBEE obligations because of skills shortages, they proactively try to create opportunities to develop the required employees with the right skillset.

2.3 SHORTAGE OF STEM-RELATED SKILLS IN SOUTH AFRICA

According to Olufemi (2005), South Africa’s history plays a major part in the shortage of skills among the previously disadvantaged; he further explains that only 10% of the black workforce was classified as skilled in 1994, also, in 1994, 97% of whites passed the high school exit level matric exam, while only 48% of blacks did and out of which only 2% of the latter qualified for science and engineering tertiary level undergraduate programmes. “Historically, the number of university graduates, especially black graduates, in science and engineering was small due to a small proportion of students pursuing studies in these fields. This can be largely ascribed to the Apartheid policies of the country that sidelined black learners in the study of science at the secondary school level” (Ramnarain & Ramaila, 2014:1)

Rasool and Botha (2011) maintain that skilled foreign workers can play an important role in supplementing the shortage of skilled workers in South Africa. A solution multi-nationals have chosen in an attempt to mitigate the effects of a local South African skills shortage has been to

bring expatriate talent into the country, includes applying for work permits for foreign experts to work in the country. This can be a long and complicated process, and companies who cannot recruit locally recognise this as being critical to the performance, success and long-term viability of their businesses. More importantly, requirements to meet BBBEE complements within local staff largely negate the cost and time required to do this. The South African critical skills shortage, especially in engineering and science among black people, is partly due to the failure of the national educational and training system to supply the economy with the much-needed skills.

It is important to note that employing foreign skills cannot be a sustainable solution as the country deals with elevated levels of unemployment rate. The South African unemployment rate is reported to be sitting at 27,2% (Moya, 2018). Moya (2018), reporting from figures released by Statistics South Africa, reports that this number has increased from 26,7% from quarter 2 to quarter 3 of 2018. The number of the unemployed people rose by 103 000 to 6.08 million in the country. Consequently, the South African government has invested in several initiatives in an effort to promote the STEM-related subjects and increase critical skills in the labour market.

The shortage of engineers in South Africa does not only negatively impact the developments related to the technology space; Wall and Amod (2007) highlight that the deficiencies in technology development caused by the extreme shortage of engineering skills impact infrastructural planning, procurement, design and construction. This suggests that there should be awareness raised to parents, learners, educators and government as to the urgency of the crisis in developing the education of qualified engineering and science practitioners in South Africa. The Engineering Council of South Africa is mandated by the South African Engineering Profession Act, 2000 (Act 46 of 2000) to conduct visits to university institutions that offer engineering programmes to ensure that the qualifications offered will be recognised by the council for the purpose of engineer registration nationally and internationally.

To further complicate the problem of scarce skills, the number of black students who enter a university engineering faculty is historically far less than that of the white students; so if the country is hopes to employ blacks to fill the critical and valuable roles, an intervention is necessary to increase these numbers. According to Schutte et al. (2016), less than 20% of all

South African qualified engineers are black. This increases the disparity between the two races qualifying as engineers and adds another challenge to local businesses with the demands of BBBEE. It is difficult to meet targets of employment equity through BBBEE as suitably qualified black engineers are not sufficiently available to hire.

Laher (2013) explains that BBBEE is a commercial incentive as companies with higher BBBEE scores are more than likely to be awarded government contracts. “When it comes to doing business with private entities, a company will score better in the BBBEE scorecard (for the preferential procurement element) if it transacts with entities with high BBBEE scores. A counterpart will, therefore, prefer to transact with entities with a high BBBEE score to increase their own score. There is, therefore, a commercial incentive for a South African company to have a high BBBEE score, as it results in it being more attractive to counterparties. This creates more commercial opportunities for that company and allows it to be issued with licenses to operate in certain industries. The Generic Codes contain a BBBEE scorecard with certain elements” (Laher, 2013).

According to Cunningham (2017), early adoption and understanding of engineering-related subjects in a school curriculum has been proven to have significant impact in broadening the high school learners’ understanding of related technology in general and as a skill that is increasingly becoming essential for companies to identify and hire in light of current technological changes.

2.4 SCIENCE, TECHNOLOGY AND PREPAREDNESS FOR THE FOURTH INDUSTRIAL REVOLUTION (4IR)

The World Economic Forum (2018) ranked South Africa at number 128 out of 137 countries, down amongst the worst in the bottom 15 of the world in the quality of its Math and Science education. South Africa is ranked below countries like Malawi, Chad and Mauritania. As the world embraces the challenges brought about by rapid developments of technology in the Fourth Industrial Revolution (4IR), it is important for South Africa to enhance its own competitiveness

by producing the skills that are ready to cope with the demands of the future. Schwab (2016) argues the 4IR will force companies to re-examine the manner they do business; he further stresses that how to find qualified talent will have to be amongst the things that need to be rethought.

"The Fourth Industrial Revolution can be defined as the revolutionary change that occurs when internet technology (IT) proliferates in all industries. It is a result of the horizontal expansion of IT. Therefore, the Fourth Industrial Revolution features the creative connection between technology and the market in all industries based on IT, that is, the creative and open combination of technology and the market through open innovation, or growth based on the open business model" (Lee et al., 2018:24). Lee et al. (2018) states that the 4IR is characterised by major disruptions, such as the fusion of robotics and artificial intelligence which will bring about a completely new process in manufacturing and services, resulting in lower labour intensity requirements. Lee et al. (2018) argues that digitalisation will be in every sector, thus generating new services. South African ex-Finance Minister, Nhlanhla Nene, in a speech in 2017, stated that "to prepare to take advantage of what the fourth industrial revolution brings along, societies must redouble their efforts in educating the workforce of the future. They can do this by addressing the need for continued and improved training in Science, Technology and Mathematics subjects. It is these subjects that will lay the foundation of prosperity during the fourth industrial revolution".

The key in this regard is how South Africa integrates the teaching of Science, Technology, Engineering and Mathematics (STEM) so that these are not treated as four specific disciplines but in a manner that will encourage and entrench an interdisciplinary approach. The disciplines of Science, Technology, Engineering and Mathematics are of critical importance for any modern society. Science and Mathematics provide answers to so many of the fundamental questions of nature and enable citizens to gain a better understanding of the world around them" (Nene, 2017:1).

Drew (2011) notes that in this high-tech global economy, finding ways to effectively teach Mathematics and Science has become of critical importance, and that STEM education must reform to improve high school Math and Science in order to handle the demands of 4IR. Foster

(2016) states that the South African government promotes Arts and Culture over and above STEM interventions, thereby neglecting to prepare South African children for the future world of robotics in the 4IR. He observes that private schools are further ahead than public schools in implementing the STEM-type complementary teaching to supplement high school Math and Science, which are the important subjects that will enhance the country's global competitiveness in the 4IR.

2.5 THE ROLE OF CSR EFFORTS BY MULTINATIONALS IN SOUTH AFRICA

Makka and Nieuwenhuizen (2018) state that the top three CSR priorities for South Africa in order of importance are as follow:

- Education, training and skills development;
- Building and development of local communities; and
- Healthcare and wellness.

Company X chose the first of this list, namely education, as its CSR initiative by embarking on the Township X Learner Excellence Project. The aim of this project as mentioned in Chapter 1 was to improve the chances of high school students from previously disadvantaged backgrounds to successfully qualify to enter an engineering discipline in a South African university. This initiative formed part of Company X's early pipeline engineer development programme. As a multinational company, Company X had to find a way to fulfil its BBBEE commitments while solving a problem of skills shortage, particularly in the industry in which it operates and in South Africa generally.

Hinson and Ndhlovu (2011:343) note that "CSR in South Africa came to be increasingly influenced by legislation and industry charters. For example, the South African Government introduced the Broad Based Black Economic Empowerment Act (BBBEE Act) No. 53 in 2003 to transform the economy".

Makka and Nieuwenhuizen (2018) argue that multinational enterprises (MNEs), such as Company X, operating in South Africa are overwhelmed by the many CSR issues calling for their

attention in the country and the lack of a national list of key CSR issues in South Africa is challenging. De Jongh (2004), Hamann *et al.* (2005), Visser et al. (2005), Da Piedade & Thomas (2006b) and Trialogue (2010) have collectively noted that the CSR issues that businesses in South Africa are confronted with include the following:

- reducing poverty and inequality;
- promoting broad-based black economic empowerment and transformation;
- promoting job creation;
- reducing crime and promoting safety and security;
- improving the quality of health care and wellness, particularly HIV/AIDS;
- tackling corruption, promoting sound governance and business ethics;
- promoting community development;
- developing and supporting entrepreneurs;
- improving education, training and skills development;
- dealing with labour issues such as diversity and employment equity in the workplace;
- upgrading and modernizing infrastructure;
- protecting natural resources and supporting environmental sustainability;
- encouraging social dialogue among stakeholders;
- developing and supporting sports;
- supporting the disabled and aged;
- promoting basic human rights and economic and social justice; and
- promoting regional integration in Africa.

These authors further argue that the decision of which CSR initiative to get involved in should depend on the current socio-economic situation of the country. Hinson and Ndhlovu (2011) mention that CSR in South Africa is not only about corporate responsibility, but also involves companies adopting affirmative action for skills development to redress past apartheid ills or injustices. BBBEE is used as a vehicle to implement these fundamental changes. Government supports companies that implement BBBEE as a vehicle to enact these fundamental changes. Although the CSR pillar may accounts for only 1% of a company's profits, this can be a significant contribution to the social development of a nation. The fulfillment of the 1% accounts for 5 points on the BBBEE scorecard. According to Hinson and Ndlovu (2011), the emergence of vigorous CSR initiatives in terms of education intervention by companies operating in South Africa has

the potential of bringing about a new meaning to business and radical transformation of the economy.

It is worth nothing that BBBEE is not the only driver for CSR in South Africa. The Johannesburg Stock Exchange (JSE) sets standards for attainment in the CSR sector for listed companies through the Socially Responsible Index (SRI) launched in 2004. SRI was formed to set apart and highlight to investors the companies on the JSE that integrate the principles of the triple bottom line into their businesses, thereby encouraging shareholder confidence and resultant investment in said companies. In return, the JSE would help facilitate investment into those companies. The three pillars mentioned on the JSE Index document (2014:2) are environmental sustainability, economic sustainability and social sustainability.

According to Kabir and Petersen (2015), civil society, including the shareholders, is also a strong driving force for company participation in CSR in South Africa. Arya and Bassi (2011) note that most South African companies have realised that in order to survive in this increasingly competitive environment, they must view CSR as a business imperative and that they need to include the Codes of Good CSR Practice as an integral component of corporate strategy. Olufemi (2005) adds that good corporate citizenship enhances companies' reputation and promotes accountability and transparency.

2.6 SUMMARY

This chapter on literature review examined the theoretical foundation of STEM-related skills for the advancement of science and technology for the previously disadvantaged. The role of STEM as a CSR initiative in filling the socio-economic gap where government cannot reach was reviewed in South African business context. The next chapter reviews the research design and methodology adopted in this research study.

The literature reviewed was also relevant to understanding important themes related to educational intervention programmes that are aimed at preparing learners for the university. The literature review revealed that STEM serves as a gateway to higher paying jobs and is an

important linchpin to a growing economy" (Sawchuk. 2018:4). The growth in demand for STEM related careers has led to a scarcity of these skills as global companies compete to attract the best skills to grow their businesses and industry. The literature review further revealed the importance of Science and Technology in the 4IR. This brought more focus on the importance of STEM-related subjects in our schools if we are to cope with the demands of the future.

3.1 INTRODUCTION

This chapter deals with the research design and methodology used in this study. The research explores the stated research problem, accepting the premise set by Company X that a high school STEM intervention programme should increase the chances of the participating learners to achieve university entry into the engineering and science disciplines. This, in turn, would have a great benefit for Company X to grow its stream of black engineers for the South African branch as a global subsidiary. This research adopts a pragmatist research philosophy. According to Saunders, Lewis and Thornhill (2016), pragmatism is interested in identifying practical and useful outcomes to solving a research problem.

3.2 RESEARCH DESIGN

The approach adopted was the inductive and interpretivist approach. Mouton (2015) notes that an inductive approach assumes that, if all the premises made during the research are true, the conclusion is probably true. Thanh (2015) describes the interpretivist approach as viewing the world through the experiences of the participants, by understanding their perceptions. There is a strong connection between interpretivism and application of a qualitative method of primary data as both seek to understand socially constructed beliefs, experiences and perceptions. Thanh (2015) states that interpretivists view the world through a series of individual eyes and choose participants who have their own interpretations of reality to encompass the worldview, therefore qualitative methods are preferred and seen as approachable means for examining reality. Interviews were conducted with the programme manager of the STEM programme, headmasters of the two participating schools and the learners (18 years and older) who graduated from the STEM intervention programme.

3.2.1 Interview schedule questions

Questions that were posed to purposefully selected participants have been formulated for the groups of people who were interviewed in this research. Ravitch and Carl (2016) note that questions can be refined as one learns more about the complex phenomenon and theories that are being researched. So the questions posed to participants often continually evolve to gain greater insight into the research problem. Ravitch and Carl (2016) proceed to explain that there must be certain conditions that allow the refinement of research questions; these conditions include:

- "An intentionality in the process of developing and refining research questions;
- Chronicling of the reasons for and influences on the key aspects of and refinements to research questions;
- Vetting of suggested changes from multiple perspectives; and
- Early and on-going data theory analysis that informs changes to research questions" (Ravitch & Carl, 2016:81).

It is important that the set questions are clear and do not confuse the people who are being interviewed. Interview questions set the rapport with the interviewee. Patton (2002) explains that it is important that the interview questions are clear and understandable as unclear questions are likely to make the interviewee feel uncomfortable, ignorant and confused. Patton (2002) clarifies that unclear questions can make the interviewee hostile.

The interview schedule questions are set out in Table 3.1 below. These questions have been formulated to gather information about Company X's STEM intervention programme to give insight into how it was experienced by the participants. "The purpose of interviewing, then, is to allow us to enter into the other person's perspective" (Patton, 2016:340).

Table 3.1: Interview schedule questions

Research Questions	Questions in questionnaire for students aged 18 and older who were part of the STEM intervention programme.
a) To evaluate the effectiveness of the STEM interventions in preparing students for the engineering discipline in a reputable university	How often did you attend the extra STEM lessons?
	Do you believe that being in the programme gave you and advantage over the other students who were not on the programme?
	In your opinion, did the STEM programme contribute to your overall success in Mathematics and Science in your final matric results?
	How did the STEM programme shape your attitude towards Mathematics and Science in the 3 years that you were in the programme?
	How has being in the programme prepared you for your tertiary education in your chosen field?
	Do you believe that being in the programme influenced you in choosing a career in the Engineering or Science field?
	Did you meet all the requirements of the STEM programme?
	Would you recommend the STEM programme to other students interested in the Engineering or Science field?
Research Question	**Questions in questionnaire for Headmasters from the two participating schools**
b) Is there any value relating to STEM high school intervention programme?	What is your opinion on STEM programmes?
	Did the programme prove beneficial to students who participated as compared to those who did not attend the programme?

	Would you recommend the STEM programme to other schools in the district?
	What would you describe as the positive impact of the programme for your students?
	What were the challenges that your students faced during the 3 years of the programme in relation to the programme?
	Questions in questionnaire for Trainer A Programme Manager
	Based on the objectives set up by Company X at the beginning of the programme in 2016, do you believe that this programme was a success and met all the objectives?
	Do you believe that STEM intervention programmes should be started in high schools or earlier for students in the public-school systems to encourage an increase in students who choose Mathematics and Science?
	Please share some of the challenges you were faced with during this 3-year programme?
	Were the initial 20 students the same students that graduated from the programme. If there were any dropouts, can you share what the reasons were for the dropouts?
	How did you maintain an alignment between the programme curriculum and what the students were struggling with in the classroom?
	What could have been done differently in this programme to ensure success for the students?
	What was Trainer A's relationship with the teachers, headmasters and the schools district officer?

Source: Researcher's own compilation, 2019

3.3 RESEARCH METHOD

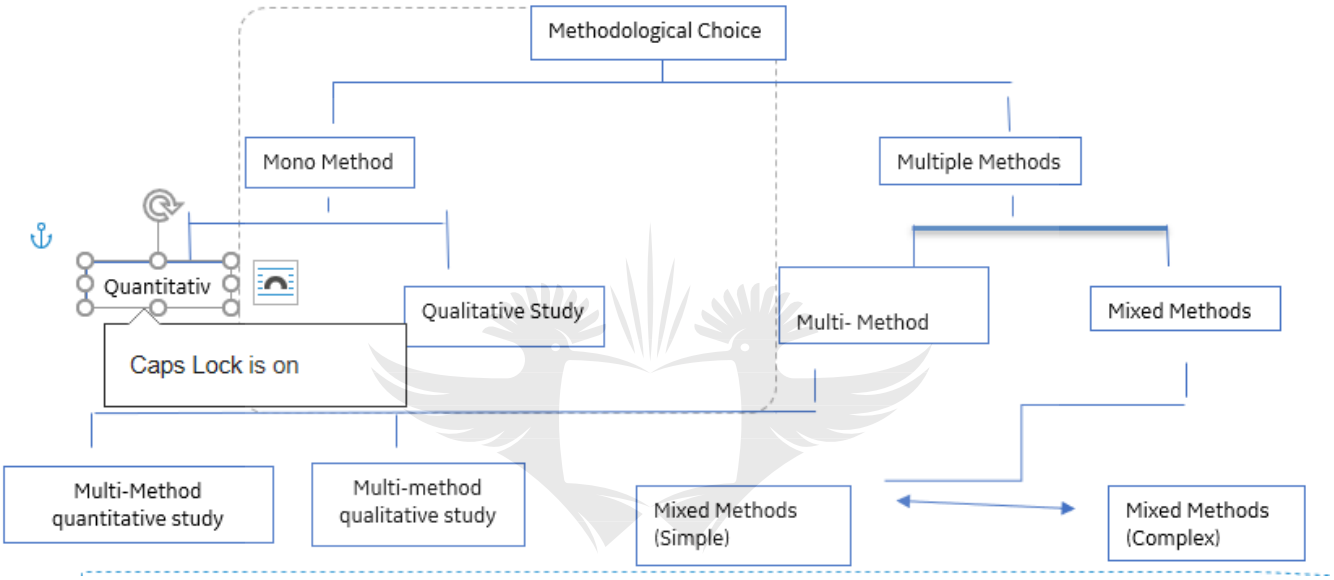
This research method adopted for this study was a qualitative method as shown in Figure 3.1 below, aimed at reviewing with deep insight the value of the Company X's STEM intervention programme. Bhattacharya (2017) states that qualitative research has its roots in anthropology, where western anthropologist would study exotic cultures, their customs and rituals through observations, interviews and archived materials. As such, the choice of qualitative method (Figure 3.1) allowed the researcher to delve deeper into the Company X high school intervention programme as to its appropriateness for the South African educational context. Ravitch and Carl (2016) explain that qualitative research is based upon the methodological pursuit of understanding the way in which various people view, see, approach and experience the world.

This research explored different stakeholder views of Company X's STEM intervention programme. This allowed the researcher to understand their experiences and if, by participating in the programme, this added value to Company X's stated goal of qualifying more PDI students for university Engineering and Science studies. Denzin and Lincoln (2011) state that qualitative research involves an interpretive and naturalistic approach to the world; explaining that this means that qualitative research studies things in their natural setting in an attempt to make sense of the meanings that people bring to them.

Ravitch and Carl (2016) state that qualitative research does not typically follow a fixed design because assessing a research problem qualitatively is based on considering multiple factors that evolve and change from the perspectives of different stakeholders. This means that the researcher needs to be flexible and must be able to adjust their questions in order to get more information. Swaminathan and Mulvihill (2017) caution researchers against reflexivity, which means being aware of hidden assumptions; they encourage that habitual patterns must be challenged in order to reframe questions to those that push at boundaries of their frame of reference. "Reflexivity requires the researcher to be vigilant and to frequently reassess their positionality and subjectivities" (Ravitch & Carl, 2016:15).

A mono-method qualitative study was followed. This means using a single data collection technique, namely the semi-structured, open ended interviews. Ravitch and Carl (2016) reflect that while this type of questioning shares key questions, unstructured interviews seek the customisation through individualising the follow up questions.

Figure 3.1: Methodological choice



Source: Saunders et al. (2016:167)

Semi-structured research strategy

This research also drew cognisance of the Program Evaluation Research, whereby a "programme evaluation is the systematic collection of information about the activities, characteristics and the outcomes of programme in order to make judgement about the programme" (Patton, 2002:10). This approach allowed for the effectiveness of the programme to be evaluated and whether the people who were part of the programme have accomplished what they wanted to accomplish.

According to Patton (2002), qualitative methods are often used in evaluations because they tell the participants' stories; they tell what happened, when, to whom and with what consequence.

The evaluation of the STEM programme gave information to Company X regarding the performance and the outcomes of the programme. This information will then help Company X to decide whether the programme has been a worthwhile CSR investment and whether this should remain one of their signature CSR programme. “Understanding the programme and participants’ stories is useful to the extent they illuminate the process and the outcomes of the programme for those who must make decisions about the programme” (Patton, 2002:10).

3.3.1 Sampling

A non-probability sampling method was followed as the sample was not random; rather focusing on the group of people involved in or affected by the project. Ravitch and Carl (2016) note that this is also known as purposeful sampling, which means that the participants have been purposefully chosen because of their knowledge and experience of a certain phenomenon; namely the Company X’s STEM intervention programme. The sample of 9 participants as indicated in Table 3.2 included 6 students (over the age of 18 years) who have graduated from Company X’s STEM intervention programme in the past 3 years, 2 men and 4 women. The researcher held the interviews with the students at their university. Ravitch and Carl (2016) state that considering the location can be an important stage of study development.

The Principals were interviewed at the offices of the participating schools. The Programme Manager of Trainer A was interviewed at his offices in Johannesburg. Due to the outbreak of the Coronavirus, contrary to the plan, the researcher could not meet the headmasters in their offices; rather, these interviews were conducted through Skype and were recorded using a recording device to capture the interviews verbatim.

The researcher gained the contact details of the two headmasters from Company X, who had authorised the study for the university ethics clearance process. The students’ details were also supplied by Company X as part of their on-going support for the students in university. The contact details for the programme manager were also provided by Company X.

Table 3.2: Participants of the research

Proposed participant type	Number	Rationale for choice
African female students who have completed the Company X STEM intervention programme at high school	4	The females were interviewed to find the connection between their success in qualifying as engineering students and the STEM programme.
African male students who have completed the Company X STEM intervention programme at high school	2	The males were interviewed to find the connection between their success in qualifying as engineering students and the STEM programme.
2 Headmasters – one each from Township X high schools running Company X STEM programmes	2	The 2 heads of schools to provide a holistic perspective by providing a view of the performance of those students who were in the program as opposed to those who were not in the programme.
1 Trainer A Project Manager	1	To get insight into the programme that Trainer A delivered to the students. The challenges they faced in the 3 years that they ran the programme for 3 years.
Total participants	**9**	

Source: Researcher's own compilation, 2019

The above table presented the data relating to the participants of the study, their number as well as the rationale for choosing them. The next table presents information about biographic details of the participants indicated above.

Table 3.3: Biographic details of the participants

STUDENTS			
Participant No	**Gender**	**Age**	**Selected field of Study**
1	Female	19 years old	Chemical Engineering
2	Female	19 years old	Electrical Engineering
3	Female	19 years old	Bachelor of Medicine
4	Male	19 years old	Aeronautical Engineering
5	Male	19 years old	Bachelor of Science in Computer Science
6	Female	18 years old	Bachelor of Science in Speech Language Pathology
Trainer A PROJECT MANAGER			
7	Project Manager		
HEAD of Co-operating High Schools			
Participant No	**Designation**	**Number of years in designation**	**Pass rate for STEM Programme Participants**
8	Headmistress	14	100%
9	Headmaster	10	100%

Source: Researcher's own compilation, 2019

3.4 DATA COLLECTION

This research was a mono-method qualitative study. Qualitative research requires in depth understanding of the research context; "its studies participants' meaning and relationships between them" (Saunders, Lewis and Thornhill, 2016). The aim of the qualitative research was

to establish the facts, study the outcomes of the programme and determine whether there is benefit to stance with acknowledgement of pragmatic context and programme review requirements, which aim to establish facts. Therefore in-depth and semi-structured interviews were conducted with the students who participated in the STEM intervention programme, principals, and programme manager. Ravitch and Carl (2016) note that qualitative interviews are relational; what that means is that they constitute a relationship and that trust and reciprocity are vital to this brief relationship. It is also important to note that qualitative interviews can also be subjective as they seek to understand the participants' interpretation and experience of a situation. "Qualitative interviews are not by definition, neutral or objective and they seek to understand people's positions, views, experiences and particular subjectivities in a number of important ways that are about understanding individual subjectivity" (Ravitch and Carl, 2016:150).

Semi-structured open-ended questions allowed both the researcher and the participants to elaborate on areas that needed clarity on the value of the STEM programme at high schools. Saunders, et al., (2016) observe that open-ended questions encourage interviewees to reply as they wish and provide extensive and developmental answers that can reveal attitudes and obtain facts. The questions focused on the interviewee's interaction with Company X's STEM intervention programme on their educational opportunities as regards entering a university for a science or engineering degree. Before engaging with the past programme participants, the heads of schools and the programme manager from Trainer A, permission has been sought and granted by Company X that sponsored the South African STEM high school intervention programme as part of its CSR. A deontological view was followed with regards to assuring ethics on this research; ethical research approval was also sought and granted by the researcher's university of study (See the university ethical clearance letter in Appendix 1). According to Saunders, Lewis and Thornhill (2016), the deontological view is based on following the rules that guide researchers' ethical conduct. The following ethical standards were observed:

- Voluntary participation;
- Participants were provided with all the information regarding the nature and purpose of the study before agreeing to participate;
- Confidentiality for all the participants and Company X was assured; and
- The study results are made available to the company and the participants on request.

One-on-one interviews were conducted between researcher and participants. The interview sessions lasted between 20 to 45 minutes, consisting of open-ended questions. The interviews were recorded on a cell phone by the researcher and transcribed verbatim to a Word document after which content analysis was conducted, reviewing the transcripts for themes found in reviewed academic literature. According to Saunders, Lewis and Thornhill (2016), semi-structured interviews are wide ranging; the interviewer may start with a set of interview themes but is prepared to vary the order of the questions and may incorporate new questions. As this research followed a semi-structured style, time management was an issue. Saunders et al. (2016) explain that it is important that interviewees can provide full answers; however this must be done within the available time.

3.5 DATA ANALYSIS

This research section provides the method of data analysis used in the study.

3.5.1 Content analysis

Content analysis is the organisation of the collected data and extracting of meaning from the data that will form part of the conclusion. Bengtsson (2016) describes qualitative content analysis as a process of finding meaning from the data collected in order to come to a conclusion. In this research, the method used to collect data was through semi-structured interviews. The process of content analysis is to simplify the data that has been collected. Bengtsson (2016) explains that the process of content analysis is to achieve rigor and credibility to make the results trustworthy.

Content analysis was used to interrogate the interview transcripts in this research. Saunders, Lewis and Thornhill (2015) describe this as a technique that is used to analyse qualitative data and involves the search for themes and patterns. In qualitative research, there is a wealth of rich descriptive data that is collected through various methods, and the research is contextual in nature. Mouton (2015) observes that in qualitative research there is a focus on individual in its

specific context of meaning and significance. Analysis in qualitative research means understanding the individual participants and may mean staying close to them. This is also known as insider perspective. According to Mouton (2015), this leads to a more holistic, synthetic and interpretative data analysis.

3.5.2 Trustworthiness

This research intended to depict the true reality of the participants' experiences, by ensuring that the data is validated with the participants and speaks to the trustworthiness of this research design and its application. The data was collected through a recording device to ensure that the findings are a true reflection of the participants' responses. Validity and trustworthiness are used interchangeably, according to Ravitch and Carl (2016), where in qualitative research trustworthiness refers to the ways that the researcher can affirm that their findings are truthful to the participants and are an accurate reflection of the participants' responses and experience. According to Saunders, et al. (2016), validity refers to the appropriateness of the measures used and the accuracy of the analysis of the results and findings. Trustworthiness or validity can be assessed through the following standards:

a) Credibility

This research reflects the participants' stated views. Credibility can be proven when the researcher demonstrates an accurate depiction of the participants' intentions. According to Saunders, Lewis and Thornhill (2016) this can be done by checking the data analysis with the participants, ensuring that the researchers preconceived expectations about the findings do not trump the social constructs of the participants. Recordings of the interviews were therefore used in the analysis of the data to ensure the credibility of what was analysed.

b) Transferability

This research provides the reader with the full information about why and how theoretically and operationally the research design was implemented, including the research questions, design, context, findings and interpretations; thereby providing the reader with full context should they want to transfer the findings to another field of interest. Ravitch and Carl (2016) explains that qualitative research is usually not designed to produce findings that can be directly transferred

to other settings and context and, in this case, the findings that can be directly transferred to other settings and context. In this case, the findings are relevant specifically to Company X's STEM intervention programme at these two high schools.

c) Dependability

Data consistency was used to validate the research design and methods applied in this research. According to Ravitch and Carl (2016) dependability infers that the researcher has given a reasoned argument for how she collected the data and the consistency in dealing with the research problem posed.

d) Authenticity

The research was deemed as fair and authentic in terms of its context and focus because it presented all the views of participants, not only the responses acceptable to the researcher.

3.6 ETHICS

The researcher acquired written approval form Company X to conduct the study on the company's STEM intervention programme. Ethics clearance was also obtained from the University of Johannesburg and was included in this study as Appendix B.

3.7 SUMMARY

This chapter explored the methods used to collect the data to answer the research questions and achieve the objectives of the study. Chapter 4 outlines the findings obtained through the empirical study conducted by means of the interviewing process with the participants.

4.1 INTRODUCTION

The previous chapter shed light on the research design and methodology adopted in evaluating the effectiveness and value of the STEM high school intervention programme in preparing students to further their education in STEM-related studies in engineering and science disciplines at university. This chapter presents the findings and interprets the results of the interviews that have been conducted with participants of this study, who include the students who took part in the STEM programme, the Project Manager in charge of running the programme and the principals who led the two schools that were part of the programme.

4.2 BACKGROUND OF THE PARTICIPANTS

A total of 9 participants were interviewed for this research. These participants were made up of 6 students, 2 headmasters and 1 Trainer A (Programme Manager). The participants participated in a semi-structured interview for the purpose of this research. Three sets of interview schedules as depicted in Table 3.1 were used; the first being for the students who participated in the STEM intervention programme sponsored by Company X, second for the programme manager who designed and ran the programme for 3 years for Company X and the last schedule was for the headmasters whose students formed part of the programme.

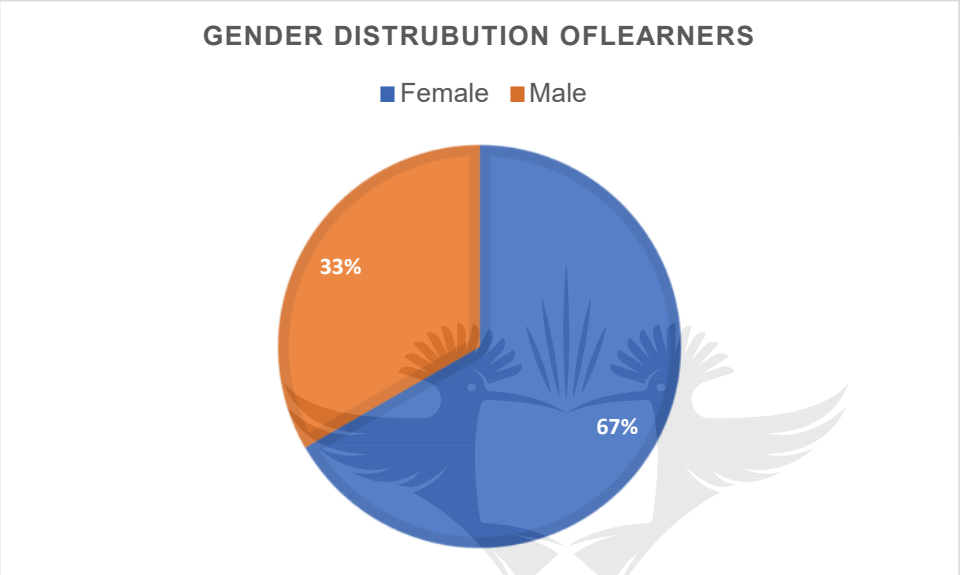
4.2.1 Profile of the student participants

This section focuses on the profiles of the students who formed part of the programme. There were six students who were part of the research. Various factors about their characteristics are presented in this chapter, such as their gender, ethnicity, current studies and place of study.

a) Gender of the students

The gender of the student participants was 67% female and 33% male, as shown in Figure 4.1 below. As explained in Chapter 1, 65% of the participants were females, thus giving female learners more of an opportunity to participate in the programme as literature shows that black females still occupy lower levels of occupation as compared to their white counterparts and/or black males.

Figure 4.1: Gender distribution of the student participants



Source: Researcher's own compilation, 2019

b) Age

Five of the six students were 19 years old, and one student was still 18 years old.

c) Ethnicity

As explained in earlier chapters, the programme was run in a black township of Township X in the eastern part of Johannesburg where the schools are based. 100% of the participants were 100% African Blacks.

d) Field of study and university entrance

The group of students who were interviewed graduated from the STEM programme in 2018 when they matriculated. All the participants received university entrance to study various disciplines at reputable universities in South Africa. They continue to be sponsored by Company X, below is the list of student participants:

- Participant number 1 received a university entrance to study Aeronautical Engineering;
- Participant number 2 received a university entrance to study Chemical Engineering;
- Participant number 3 received a university entrance to study Electrical Engineering;
- Participant number 4 received a university entrance to study Bachelor of Medicine and Surgery;
- Participant number 5 received a university entrance to study Bachelor of Science in Speech language Pathology; and
- Participant number 6 received a university entrance to study Bachelor of Computer Science.

4.2.2 Profile of Trainer A: Programme Manager

Mr Trainer A has been with the Training Company A for a period of 6 years in his role as Programme Manager. He has over 20 years' experience in various positions in Education, including as Teacher, ABET Centre Manager, Gauteng Education Department Technology Provincial Coordinator, Gauteng Education Department eLearning Provincial Coordinator and Science Centre Manager. He holds a Bachelor of Education Honours Degree in Technology Education, Bachelor of Education Degree in Computer Applications Technology and Master of Education Degree in Theology.

4.2.3 Profile of Principal A

Ms Principal A has been a principal at AA Secondary high school since 2006. She has been in the teaching profession for more than 31 years. All the responses from Ms Principal A have been laid out in Table 4.12 below.

4.2.4 Profile of Principal B

Mr Principal B of BB Secondary School situated in Township X has been a principal at the school since 2010 and thus possesses about 10 years of experience as the principal.

4.3 PRESENTATION OF FINDINGS

Using content analysis, in the next section the researcher has extracted direct quotes from the students, school principals and trainer interviews to make points as regards the themes that have arisen in the literature review (Chapter 2) regarding the value of a STEM intervention programme. The responses were broken down and grouped together in order to extract the common or recurring themes. The University of Colombia website explains that in order to analyse text using content analysis, the text must be broken down into manageable categories, after which it can be summarised into themes.

4.3.1 Findings relating to the interviews with the students

The interview responses are presented verbatim to bring across the students' genuine views about the STEM intervention programme of which they have been from 2016 to 2018, sponsored by Company X.

The researcher grouped the students' responses by questions in order to enable comparing the varied responses by the different students to the same questions. To ensure anonymity, all the participants are described by their field of study, age, gender and place of study.

a) *Question 1: How often did you attend the extra STEM lessons?*

The above question, as reflected in Table 4.1, sought to establish if these students had the full experience of the programme and therefore could provide qualified responses based of full experience of the programme as opposed to someone who attended occasionally.

Table 4.1: How often did you attend the extra STEM lessons?

Participant	Response
Aeronautical Engineering Student 19 years old, male	"Every Saturday, for a period of two years"
Chemical Engineering student, 19 years old, female	"99%, every Saturday from 2016-2018"
Electrical Engineering Student, 19 years old, female	"I can say, every Saturday from 2016 to 2018"
Bachelor of Medicine and Surgery student, 19 years old, female	"All Saturdays classes, every year 2016-2018, winter classes and all but 1"
Bachelor of Science in Speech Language Pathology, 18 years old female	Attended every Saturday for the first 2 years and started missing some lessons in 2018, because the school developed their own programme for matric learners.
Bachelor of Computer Science, 19-year male	Every Saturday, even during the school holidays we attended.

Source: Researcher's own compilation, 2019

It was clear from the above responses to the first question that the selected students were qualified to give a well-informed view of the STEM intervention programme based of the fact that 90% of the participants attended the classes religiously for the timeframe set forth.

b) *Question 2: Do you believe that being on the programme gave you an advantage over other students who were not on the programme?*

This question, framed in Table 4.2, set out to figure out if the students who participated believed that by being in the programme put them in a better position as compared to their counterparts who were not in the programme. The responses from the participants should give us information about whether or not the students felt that there was clear value by being in the programme when they looked at the other students who were doing Mathematics and Science but not in the programme. Table 4.2 also provides the students' views on whether being on the programme gave them an advantage over those students who were not on the programme or not.

Table 4.2: Do you believe that being on the programme gave you an advantage over other students who were not on the programme?

Participants	Response
Aeronautical Engineering Student 19 years old, male	Definitely gave me an advantage. Okay, it's like at school we learn things but if you get to do it more and more, you eventually become comfortable with it. We eventually became comfortable with some of the things. I remember in 2017 we were experimenting seeing is believing basically, so it gave us an advantage, like we know what we are expecting and best suited to tackle problems in our academic life.
Chemical Engineering student, 19 years old, female	Definitely, it was the best thing that ever happened to me in high school. My marks improved after joining the programme, because judging from before the programme started my marks were bad, actually horrible and after I joined the programme, they improved after that.
Electrical Engineering Student, 19 years old, female	Yeah, because my grade 10 marks were fine but after I joined the programme, things improved because I was getting extra lessons. Some of the things I learned more than I learned at school because sometimes, like, I don't even hear what the teacher was saying, so like not gonna miss you on Saturday.
Bachelor of Medicine and Surgery student, 19 years old, female	Definitely did, I felt that the Maths teachers gave more resources than we got in school. Some methods were better than what was used in class.
Bachelor of Science in Speech language Pathology, 18-year-old female	Yes, it did for the first two years but in 2018 it wasn't. In 2018 there was a programme at school and Trainer A changed teachers, that I could not understand as well. So,

	I decided to attend the school programme, I alternated between the two.
Bachelor of Computer Science, 19-year male	Yes, it did give me an advantage, because before I was on the programme, I was not serious with my school work, so they gave me that pressure to work hard, before I would settle for 60% but when I was on the programme I wanted to get the highest mark I could. They changed me, if I can say.

Source: Researcher's own compilation, 2019

Based on the responses in Table 4.2 above, the students saw an advantage in being on the programme. Some felt that the repetition of concepts contributed to the improvement they saw in their marks while others believed that the Trainer A tutors had better resources to share during the Saturday classes and there were better methods used in the Saturday classes. Although the general feeling was that the programme put them in an advantageous position, one student believed that the last year of the programme was not as beneficial as the first two years. The student explains that Trainer A introduced new teachers on the last year which was a problem for this particular learner. The majority of the students believed that they were better positioned by being on the programme.

c) *Question 3: In your opinion did the STEM programme contribute to your overall success in Mathematics and Science in your final matric results?*

This question, as shown in Table 4.3, sought to probe the direct relationship between the programme and the final Mathematics and Science outcomes of the learners. The question probed whether there was a direct association between the Saturday lessons and the final matric results. The programme was established with the intention of influencing the final Maths and Science results of these students.

Table 4.3: In your opinion did the STEM programme contribute to your overall success in Mathematics and Science in your final matric results?

Participant	Response

Aeronautical Engineering Student 19 years old, male	Yes, it did without a doubt. Without Trainer A coming in and testing us every week. Exercising our brains every week. I would have not achieved what I achieved, like you know I wouldn't had gotten those distinctions or anything. I think that I might have gotten them but not the way that I acquired them. You can be talented but talent without hard work, it's just a waste, you know, it's a waste. So, it definitely contributed to me achieving the marks
Chemical Engineering student, 19 years old, female	Really did. The first term of grade 12 my marks were very poor until they brought in Mr X, he is the reason why I got a distinction in Maths.
Electrical Engineering Student, 19 years old, female	I can say that the material that they gave us was very helpful. It did contribute. But I had a problem when they changed teachers in matric. It's like you knew how to approach a certain person and you knew how they explained it and you understand it. So, with them changing teachers in matric kind of disturbed it a bit. But I got back on track and yeah it contributed
Bachelor of Medicine and Surgery student, 19 years old, female	Yes, maths results were better than I could have expected. Got a distinction in Maths. There was more engagement on Saturdays. English was quite helpful; on Saturdays they did more the basics of how to construct a sentence.
Bachelor of Science in Speech language Pathology, 18-year-old female	Yes, it did.
Bachelor of Computer Science, 19-year-old male	Yes, it did. As I said before I was not that serious with my schoolwork. When I was attending there, they wanted me to get a minimum of 70% for matric and they also say that they

	would not take all of us for the bursary for University, so we had to compete. I got 98% for Math and 91% for Science

Source: Researcher's own compilation, 2018

In their responses to the question posed in Table 4.3, the students felt that the programme did influence their success in Maths and Science in Matriculation year. One student added that the benefits of English was greater as one of the subjects offered as part of the programme. The students mentioned that they believed they received distinctions in matric for those subjects because of the programme. These responses directly correlate with the aim of the programme, which was to influence the final Maths and Science results through this particular intervention programme.

d) *Question 4: How did the STEM programme shape your attitude towards Mathematics and Science in the 3 years that you were on the programme?*

The aim of this question was to determine if the students' attitudes towards the subjects changed during their time on the programme and whether or not the programme had a positive influence on the students' attitude towards these subjects. The responses are provided in Table 4.4 below.

Table 4.4: How did the STEM programme shape your attitude towards Mathematics and Science in the 3 years that you were in the programme?

Participant	Response
Aeronautical Engineering Student 19 years old, male	Yeah. In that, I think that shaped like the overall view, how I view this, how I see Mathematics and science. It's like if everyone can have the certain mindset that these things are not things. But science is something that happens daily, it's a process that happens daily. What I do is Mathematics. It's like the way I view things. It shaped the way I view things. I used to view things I a tunnel vision, now I see things on the

	other side and my view shifted. It changed my understanding of these things.
Chemical Engineering student, 19 years old, female	So, it taught me that with such subjects you have to have discipline and also be motivated to get the good marks that you want, and that you also need the support from your teachers and also be able to communicate with them and be willing to work hard for your goals
Electrical Engineering Student, 19 years old, female	So, I would really give credit to my Trainer A teachers, they did a good job. They did a good job; I would not lie. When it comes to Physics my other teacher from back at school was really good. But Saturday classes, I felt I was in class, they really go to explain everything to me, and they made me fall in love with Physics. I was really bad at physics, really bad. I didn't have that thing to study physics. I was like, I am just doing physics because I chose it after all.
Bachelor of Medicine and Surgery student, 19 years old, female	It made me fall in love with maths, because of the engagement and got me more active in class.
Bachelor of Science in Speech language Pathology, 18-year-old female	We had a lot of talks about how Math and Science is important and being in the programme gave me a positive attitude towards the subjects.
Bachelor of Computer Science, 19-year male	With the extra lessons, they were teaching us things that we were not learning at school. I have always loved Math but did not love physics. They made me love physics.

Source: Researcher's own compilation. 2018

The students' responses as tabulated in Table 4.4, point to a programme that did not only help them to attain distinctions but also changed their attitudes towards the STEM-related subjects, such as Maths and Science. All the students agreed that they developed a positive attitude towards the subjects, with some even adding that "they fell in love with the subjects" because of

the programme. This proves that the programme had a positive influence on the students' perception of the STEM-related subjects.

e) *Question 5: How has being in the programme prepared you for your tertiary education in your chosen field?*

This question sought to understand to what extent, if any, the programme helped the students to better adjust to tertiary life. The question as stated in Table 4.5 examines if the students felt they were better prepared through the programme for tertiary life when they started tertiary in 2019 and. whether being on the programme helped them to adjust to the level of teaching at university because they had extra lessons and resources in high school through the programme.

Table 4.5: How has being in the programme prepared you for your tertiary education in your chosen field?

Participant	Response
Aeronautical Engineering Student 19 years old, male	Academically, Yes, I am well prepared, but I can say that socially as a person. There could have been more exposure to the Universities. There was only one session a month with X Careers where we drafted out our dreams and that. But I feel like the social, to find who you are. The distinctive trait that you have socially, you know. When we came here academically, you can say we were fit but socially, no interactions all of that.
Chemical Engineering student, 19 years old, female	Honestly, it didn't prepare me at all. That was the only missing aspect. If only that was there everything would have been better. Maybe if we were exposed to coming to Varsities, maybe do some job shadowing. That would have helped
Electrical Engineering Student, 19 years old, female	I had to be prepared emotionally, X Careers prepared us emotionally but there was no follow up. I felt like when we got here, I was on my own. We didn't get emotional support like we got in high school. So, they were like this is how it is

	going to be. But they didn't check on us. Nobody was checking on us to see how we are coping in varsity. We really appreciate the funding but there was no support to check on us.
Bachelor of Medicine and Surgery student, 19 years old, female	Most of the things we did on the programme were more focused on Math and Science. I feel that I was not properly prepared for Physics for better preparation.
Bachelor of Science in Speech language Pathology, 18-year-old female	X careers which was part of the Saturday programmes came every 3 weeks and teach us about how life is and they would help us apply and tell us about different Universities, different careers and courses that we can do and that made me more aware of the options that are out there. We also had a workshop last year organised by Trainer A, which focused on helping us with time management, finance management and different ways to succeed in University and introduced us to other Trainer A students in our institutions.
Bachelor of Computer Science, 19-year male	As part of the programme we had a career section that taught us more about life at University and career choices that existed, they really helped. It made it easier when I started last year, like having to be more independent than depending on lecturers.

Source: Researcher's own compilation, 2019

This question drew different responses from the students; some students felt that they were prepared academically but socially they were not prepared for university and that brought them some difficulties. The students mentioned that as part of the Trainer A and Company X programme, there was a life skills part that formed part of their Saturday classes every third Saturday and it was called X Careers. On the other hand, other students felt that they were prepared academically and emotionally, since they felt that there was no support at university to ensure success as they dealt with the changing environment of tertiary life. This suggests that

supporting only the academic side is not enough to ensure success for these students at university.

f) *Question 6: Do you believe that being in the programme influenced you choosing a career in the 'Engineering' or the 'Science' field?*

Company X started this programme because of the scarce engineering and science skills in South Africa; it is therefore important in Table 4.6 to examine if these students chose engineering and/or science as a result of the programme to understand the influence that the programme had in the students moving to engineering or the sciences.

Table 4.6: Do you believe that being in the programme influenced you choosing a career in the 'Engineering' or the 'Science' field?

Participant	Response
Aeronautical Engineering Student 19 years old, male	No, it was always my dream to do what I am doing. I always knew what I wanted to do.
Chemical Engineering student, 19 years old, female	Yes, it made me fall in love with it more. And it showed me that there are many opportunities in Engineering field.
Electrical Engineering Student, 19 years old, female	Absolutely, at first, I did not even know what I wanted to be. My Trainer A physics teacher introduced the topic of electricity and I said yeah, I like that electricity something, so when they asked me what I wanted to be I said Electrical Engineering, I like that.
Bachelor of Medicine and Surgery student, 19 years old, female	X careers helped in preparing me for the future. They helped me realise what I wanted to do in varsity
Bachelor of Science in Speech language Pathology, 18-year-old female	Yes, it did. They helped me to know that there are other careers out there such a BSC in Speech, language pathology. I didn't know it existed, given my background.

Bachelor of Computer Science, 19-year-old male	No, I already knew that I wanted to do Computer Science, so they did not change anything.

Source: Researcher's own compilation, 2019

Responses in Table 4.6 show that more than 50% of the students decided to study Engineering or the Sciences as a result of the programme, because of the exposure that the programme gave them in different career paths. This proves that the programme did indeed have an influence in these students choosing the career paths that they did. There is only one student who always knew what he wanted to be, and the programme helped him reach that.

g) Question 7: Did you meet all the requirements of the STEM programme?

As part of the programme, there were requirements set out by Company X for the students to achieve in order to remain part of the programme. The requirements were that the students had to achieve a 70% pass mark for both subjects in order for the company to carry on sponsoring them as they go into University.

Table 4.7: Did you meet all the requirements of the STEM programme?

Participant	Response
Aeronautical Engineering Student 19 years old, male	Yes, it was not hard
Chemical Engineering student, 19 years old, female	Yes, I met all the requirements of the programme
Electrical Engineering Student, 19 years old, female	Yes, like in matric they wanted, 70%and I did that
Bachelor of Medicine and Surgery student, 19 years old, female	Grade 10 was difficult to manage to meet the requirements, but at the end I did for Maths and Science

Bachelor of Science in Speech language Pathology, 18-year-old female	Yes, I did. I got 70% for Maths in matric and 68% for Science.
Bachelor of Computer Science, 19-year-old male	Yes, I did meet the requirements for the STEM programme. I had to get 70% and I got 98% for Maths and 91% for Science.

Source: Researcher's own compilation, 2019

Based on the responses in Table 4.7, all the students met the requirements set out by the programme in their final year in matric. The requirements were 70% at the end of each year. Although some of the students struggled in their earlier years on the programme, in the final year they all achieved the required marks as set by Company X.

h) *Questions 8: Would you recommend the programme to other students interested in entering the Engineering or Science field?*

This question examined the effectiveness of the programme and probed whether or not the students felt that this programme should be rolled out widely and would it present a better opportunity for other students. The aim of the question in Table 4.8 below was to probe if the students felt that the level of success they have achieved can also be experienced by other students after them.

Table 4.8: Would you recommend the programme to other students interested in entering the Engineering or Science field?

Participant	Response
Aeronautical Engineering Student 19 years old, male	Definitely, would, because opportunities like that are like a boost you need to get the support that you need to get where you need to be.
Chemical Engineering student, 19 years old, female	Definitely, because it helps you to be sure of what you want to do and helps to improve marks to get into the engineering field

Electrical Engineering Student, 19 years old, female	Yes, because it is like a foundation of what you will be doing in engineering. But your marks also determine whether you will do it or not.
Bachelor of Medicine and Surgery student, 19 years old, female	Yes, would recommend the STEM program. English and Science are in every module. Important for learners to get the extra resources
Bachelor of Science in Speech language Pathology, 18-year-old female	Yes, I would recommend it. It gives you more time to practice Science and Math. You get to improve your marks and not scared to get new information from new people. We also got more question papers to practice with.
Bachelor of Computer Science, 19-year-old male	Yes, I would because it will change their lives as it changed mine. They will get to learn more things than we learn at school

Source: Researcher's own compilation, 2019

As per Table 4.8 above, there was consensus among the students as they all believed that being on the programme was an opportunity that they would recommend to others.

4.3.2 Findings relating to the interview with Trainer A: Programme Manager

In this instance, the researcher did not separate the questions as this was an interview of one person. Mr Trainer agreed to meet me at the Trainer A's offices to be part of the interview. All the questions and answers are set out in Table 4.9.

Table 4.9: Presentation of findings from the interviews with the Trainer A: Programme Manager

Questions	Response
Based on the objectives set up by Company X at the beginning of the programme in	Without any shadow of doubt, I believe we met all the objectives.

2016, do you believe that this programme was a success and met all the objectives?	
Do you believe that STEM intervention programmes should be started in high schools or earlier for students in the public-school systems to encourage an increase in students who choose Mathematics and Science?	Yeah, earlier for me will be subjective number one. We have got three phases in schools with what foundation? We've got GET and we have what FET. And, what my suggestion would be, is that we need to start this at the GET is grade seven, eight and nine, okay? And then FET is grade 10, 11 and 12. GET phase the subjects are all combined. Okay, you have mathematics is with mathematics, mental and physical sciences in the GET is combined with life sciences and geography. Its natural sciences are quantum nature of sciences, so it's a combination. So, if you started in the in the GET, you cultivate an appetite for these learners to choose pure mathematics. And choose physical sciences over and above other subjects so you know who you will be dealing with. Because that other one is natural sciences is just a combination that prepares them for everything. So, it will be better to start with your grade seven eight and nine. And when they make their subject choices, they make their subject choices based on their understanding that they are going to Life orientation is a subject that should guide and support these learners to choose their careers of the subjects they need to choose in the FET. But if it has not been it has not been implemented properly. This could lead us don't know what to do. Then it is the, parents and many other external factors that determine So, but in our case, would have preferred to start earlier would be GET not foundation. So that would be grade seven and nine when they actually make their choices.

	The programme started at grade 10 so we are finding learners that have already made that particular choice. And they've made that particular choice with some content gaps. That is why always will be fighting with the funder to actually say please understand these leaners have got content gaps, and then we need to work on the content gaps before because the promotional requirements of the Department of Education is based on age cohort number one. Number two, you cannot repeat a phase twice okay. So, if you fail grade seven, you will be promoted to grade eight or nine. Without actually passing, yes without actually passing Yes, that is what I wanted to say. You repeat once, then you proceed, that is why we have inherent and accumulated content gaps that we deal with. So, you may find that a child passes natural sciences very well, but there is a catch that natural sciences may be 50% was biology 50% towards the physical sciences, then that child passed but it is life sciences, not physical sciences and when he gets through grade 10 he struggles because physical sciences was not his strength or the teacher was not competent enough to do that. So, when we intervene earlier, we know that all the strains of physical sciences have been covered and there is foundation then you move and the other one as an age cohort, and the other one is that is the provisional requirement. Yes. So, so starting earlier would actually assist.
Please share some of the challenges you were faced with during this 3-year programme?	One of the challenges is that learners comes with a lot of content gaps. They come with a lot of content gaps that we need to close up before we can proceed. That does not all go well with the funder because the funder is expecting results and we are still closing the gaps. That is

	the challenge to make the funder understand the situation that we find ourselves in. So, it takes a toll on us to make you understand. You see, when you are not in the education sector, it is very difficult to understand what is actually happening in education. So, it's the content gaps of the learners. That is number one. Number two, is convincing the funder to understand that and these are the challenges and we will overcome them. I gave you two. The third one, stakeholder management and what have already we have spoken about the funding the stakeholders, it's the ones that gives us a lot of problems, the schools themselves. When you start in grade 10 and 11 everything's fine. But when you get to matric, then there are issues. Number one, the project you're only giving three subjects which is Math, Science and English but for the child to pass you need all the subjects. In matric the school run programmes to support the learners in all the subjects, then the rate of absenteeism increases for the Saturday classes, because the students have to attend the programmes arranged by the schools. Then the threats from the school side also increase because our system is measured by the performance of matrics. Their teachers will be running their own extra classes on a Saturday. So those learners will choose to go to that programme. If they don't go, they get penalised. They don't get what we call the year mark it's called the pass mark, which is continuous assessment, which makes 25% of the 100%. It is two ways it's for the pass mark which is the year mark. It is also for other subjects that we are not offering for example, we have not been offering geography we do not offer Life Sciences in many others and the child is saying Okay, I need this so that I can meet my university requirements for me to get the good grades and stuff like that, those are some of the

	challenges that are very much, much. Just to summarize for you, you can bullet them it is content gaps which is accumulated because of progression. It is the stakeholder management making the funders and everybody else to understand it. And it is the competition for the learners that happens, especially in matric those are some of the t challenges that I can highlight that gives us sleepless nights. But when we start in grade 10 everything's fine and when they see the performance and see that this is a distinction material, okay. Now, we must support this child fully.
Were the initial 20 students the same students that graduated from the programme. If there were any dropouts, can you share what the reasons were for the dropouts?	Yeah, there where dropouts very minimum, I think we had less than five dropouts. One that I can cite I think it was teenage pregnancy and the others, it was mainly performance, because the program is structured in such a way that you can withdraw and replace lenders in the first two years of intervention. And we withdraw based on the three criteria. One, its performance, they must meet a minimum of 50% at the end of the year, in each and every subject, they must not be absent for more than three Saturdays in succession, without giving any valid reason. And the third one is conduct we cannot accept learners that are stabbing one another or beating one another and all those, then we would withdraw them. But the girl learners again, like I said earlier, if they're coming from child headed families, I think in one instance in Township X this girl was staying alone. And when we dug further, the parents had all passed on, I think they were HIV positive or something. And she also abused and had to drop off. Yeah, so we couldn't finish with the same cohort that we started with because people take advantage of those learners.

How did you maintain an alignment between the programme curriculum and what the students were struggling with in the classroom?	Yeah, that one is easy because the school curriculum is there for everybody to see. What we do is that whatever they've done during the week as per CAPS, is consolidated over the Saturday, our sessions, is 90 minutes, what we do the first 30 minutes we assess whether there was teaching and learning in the class that we evaluate that, identified those particular gaps, then provide teaching, close the gaps. If there are any but if there has not been any gap, then you teach new content. And then the third 30 minutes, then you evaluate. Yes, remember, from Monday to Friday, they should have covered this much but you are not aware. These kids are coming from different schools, and a teacher may have been absent. And they may not have been teaching and learning or the shortage of teachers and staff. So, you need to do that as a teacher. And then you align that, because the results of Trainer A do not matter much, but this school's results matter. Yes. So, although we assess ourselves, we need to align because when they write their cycle test, first term, second term, third term, these are school results that matter, so we need to be teaching them what they are doing at school. So, it's an enrichment kind of a program which is what we call excellence.
What could have been done differently in this programme to ensure success for the students?	Most of the things according to the program design has been covered. What could have been done differently was the role modelling part of it, for example, where we have an engineering company in the form of Company X. We should draw more of those particular engineers to come and talk to the learners in learners must be able to say, this is XX, and she grew up almost the same as me. Maybe she's from a rural village in KZN or Limpopo, but here she is, it means I can also do it. So, we needed more of that career guidance,

	the mentorship and the support. And just, to remove these kids out of their cocoons and begin to say, I'm not alone in this situation. And the current situation that I find myself in is not me, my destiny still there. So those are some of the things but given the limitations, maybe your budget, availability of staff, availability of mentors, those are some of the things that could be of a hindrance. Otherwise, most of the things in terms of curriculum and teaching the curriculum, they have been covered
What was Trainers A relationship with the teachers, headmasters and the schools district officer?	The relationship it is fluid like I've indicated before, when you start everything is fine, the problems starts in matric. Because now the schools are beginning to say okay, when this learner need to be offered more subjects, then the problem is one. We've already signed the contract with Company X, that we are only going to service pure mathematics and physical sciences and English we cannot change and when we do not do that, they begin to come up with strategies to solve. The problem is mainly in matric when we started, everything is fine and everybody's supportive. Worse, you have challenges, especially in matric because these learners go to camps in the semester, especially in Gauteng, you have the secondary school intervention programmes. So, those are some of the things and they are being organized centrally by the province. And then the, the sort of create a wedge between our offerings and end payers. So, in summary, I would say when we start the relationship is very good. You would have seen when we started everybody attended the meetings, but towards the end, especially the matric, very few people come because now we no longer talk the same language. They want to do this they want us to add and we

	cannot chop and change along the way. That is, the issue. The relationship we have with the learners is good with the parents is good. It doesn't change, it remains the same because they can see the benefits, they can see the support.

Source: Researcher's own compilation, 2019

Summarising the responses in Table 4.9, the Programme Manager believed that they met the requirements set by Company X when the programme started, notwithstanding the challenges that they faced along the way. He believed that the programme was a success based on the set-out requirements and the matric results of the students who were on the programme where they achieved 100% pass rate. When asked whether he believed that such programmes should start earlier, he responded by saying not as early as foundation. It should start in General Education and Training (GET) when the students start to be exposed to core Mathematics, Science and Physics; when there is a separation of the subjects would be the best time to start.

Mr Trainer listed the challenges he faced as per below:

- He explains that when they start with the students there are content gaps that they need to fill in order to get the students up to par before they can start with the work at hand. He explains that the system does not allow children to fail a grade twice, which means that there are children who are allowed to pass while they do not qualify to pass and that is what results in content gaps;

- Filling the content gaps takes time but sponsors do not understand that because they are not in the education field. Managing the stakeholders becomes a challenge because they want results not realising that there are challenges which pertain to content gaps and they take time to fix; and

- During the matric year there is competition for the students with the schools. The schools start their own programs for matric to make sure that their students are successful, this means that students start missing the Trainer A Saturday classes to attend the classes

set up by the school, that increases absenteeism. This is a big challenge for the final year of study.

When asked about the dropouts, Mr Trainer A explained that there were social problems that resulted in some students dropping out of the programme. He mentioned two incidences, one the student fell pregnant and the other had lost both parents to HIV and lived alone with no support. This highlights the environment that these learners came from and the challenges they faced as school going young people. He added that the programme fed the learners on Saturdays because some students had no food at home; so the auxiliary part of the programme was feeding the students. This was paid for by Company X. When asked about maintaining alignment with the school, he explained that, that was easy because the curriculum was set and was there for everyone to see. What they had to do was make sure that what was supposed to be covered was covered at school, if not they covered the content or expanded on concepts introduced in class. This allowed flow for the students and the concepts were covered on both ends.

Mr Trainer A believed that Company X could have played a bigger role, than just being the funder. Seeing that Company X is a company full of engineers and other academically qualified professionals, he believed that they should have been more in contact with the learners to talk them through their careers and how they achieved what they achieved. He believed that this would have been a great addition for the students and would have given them more insight into the world of work.

When asked about the relationship with the headmasters and teachers, he explained that at the beginning of the programme the relationship was good. But things changed when they got to matric as they started competing for the students' time since the school formed its own programmes and forced the students to attend. The problem here was that the Trainer A project only offers 3 subjects when the schools programmes incorporates all the subjects in order to help their students to succeed in all the subjects.

Table 4.10 shows the Top 10 students in 2018 who attended the Trainer A programme sponsored by Company X. Four of the students interviewed for this research were part of the

list, highlighted below. Table 4.10 illustrates the success of the students who were on the STEM intervention programme.

Table 4.10: Trainer A's Top Learners 2018

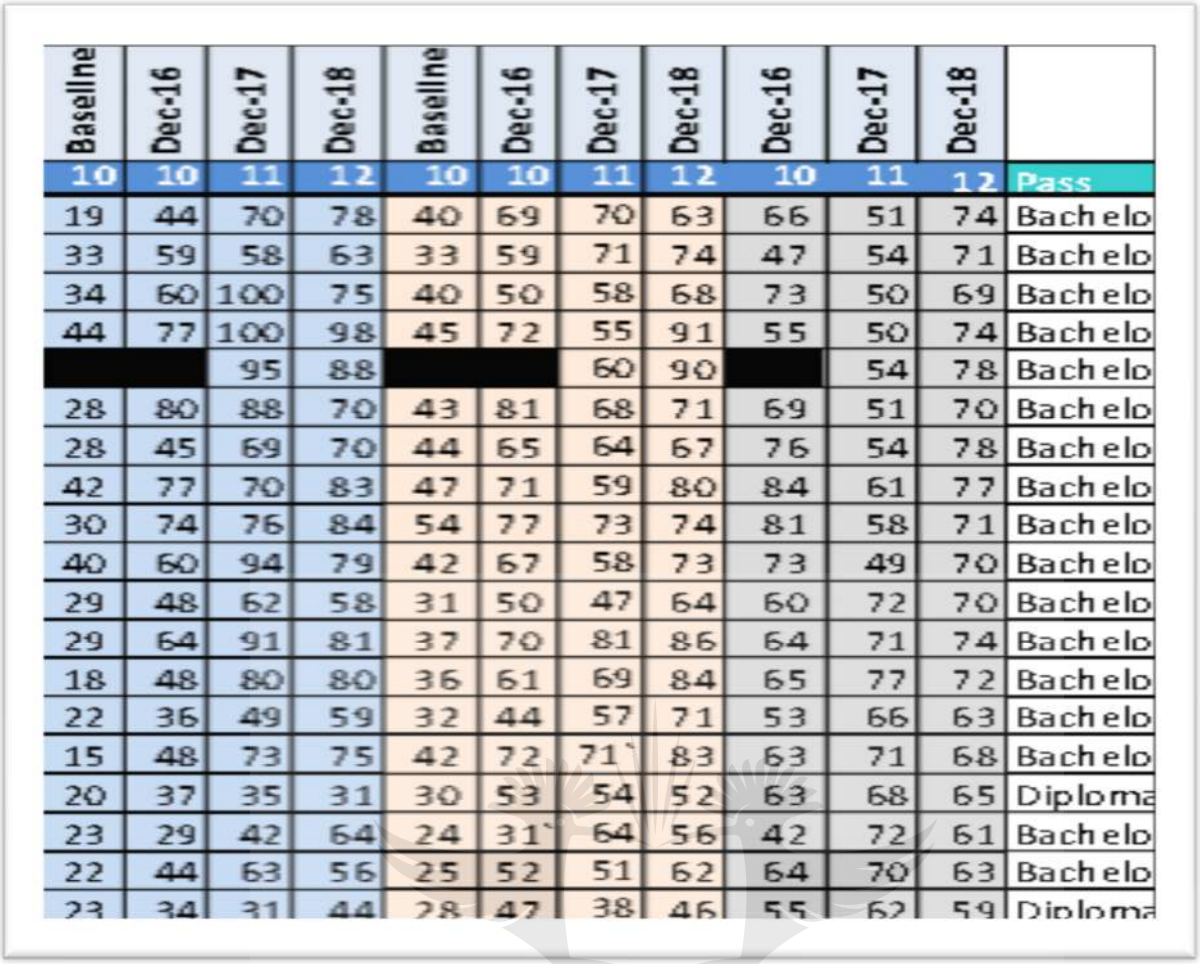
Top Performance Learners 2018						
Exam Number	**English**	**Math**	**Physical Sciences**	**Total**	**Notes**	**Interviewed learners**
8182607600084	74%	98%	91%	263%	4 Distinctions	Aeronautical Engineer
8182607600096	78%	88%	90%	256%	3 Distinctions	Computer Science
8182607600134	77%	83%	80%	240%	4 Distinctions	Medicine
8182607600155	71%	84%	74%	229%	1 Distinction	
8184001150072	68%	75%	83%	226%	3 Distinctions	
8184001150052	72%	80%	84%	236%	5 Distinctions	Chemical Engineering
8184001150037	74%	81%	86%	241%	6 Distinctions	

Source: Provided by Trainer A January 2019

Table 4.11 shows the learners' journey from the beginning of the programme to matriculation. The table shows the marks achieved by the learners at the beginning of the programme when they were initially assessed. It then shows how each student improved their marks for Maths, English and Science respectively. For example, the first line is of a student who started the programme with a 19% baseline in Maths to achieving 78% as their final year matric result; they started with 66% in 2016 for Science to 74% for matric.

An analysis of the below results supplied by Trainer A in Table 4.11 demonstrates the learners' progress over the period of the programme. The results show the 19 students who completed the programme; 32% of the learners received marks below 70% for Maths, Science and English. While 68% of the participants improved their marks in the 3 years and received over 70% for the 3 subjects.

Table 4.11: Result Analysis from 2016-2018



Baseline	Dec-16	Dec-17	Dec-18	Baseline	Dec-16	Dec-17	Dec-18	Dec-16	Dec-17	Dec-18	
10	10	11	12	10	10	11	12	10	11	12	Pass
19	44	70	78	40	69	70	63	66	51	74	Bachelo
33	59	58	63	33	59	71	74	47	54	71	Bachelo
34	60	100	75	40	50	58	68	73	50	69	Bachelo
44	77	100	98	45	72	55	91	55	50	74	Bachelo
		95	88			60	90		54	78	Bachelo
28	80	88	70	43	81	68	71	69	51	70	Bachelo
28	45	69	70	44	65	64	67	76	54	78	Bachelo
42	77	70	83	47	71	59	80	84	61	77	Bachelo
30	74	76	84	54	77	73	74	81	58	71	Bachelo
40	60	94	79	42	67	58	73	73	49	70	Bachelo
29	48	62	58	31	50	47	64	60	72	70	Bachelo
29	64	91	81	37	70	81	86	64	71	74	Bachelo
18	48	80	80	36	61	69	84	65	77	72	Bachelo
22	36	49	59	32	44	57	71	53	66	63	Bachelo
15	48	73	75	42	72	71	83	63	71	68	Bachelo
20	37	35	31	30	53	54	52	63	68	65	Diploma
23	29	42	64	24	31	64	56	42	72	61	Bachelo
22	44	63	56	25	52	51	62	64	70	63	Bachelo
23	34	31	44	28	47	38	46	55	62	59	Diploma

Source: Provided by Trainer A January 2019

4.3.3 Findings relating to the interview with Principal A

The following table presents the findings relating to the interview with Principal A.

Table 4.12: Findings relating to the interview with Principal A: the Headmistress

Questions	Response
What is your opinion of the STEM programme?	The programme was beneficial for the students especially because at the school we did not have competencies and

	stuff and they benefited from Company X, also when they were taken for job shadowing, they also learned a lot from that. Usually people look at a company from outside and don't know the different careers inside, so it made them to be wide open and learn other careers. When they interact with people who are in the game is better than interacting people who talk about careers, they don't have exposure to. I believe they benefited a lot. The Teacher also go exposure by interacting with the tutors. Teachers who are competent and want to know what this guy is doing with my kids, so at the end of the day they share. The interaction with other students and tutors made the students a team.
Did the programme prove to be beneficial to your students who participated as compared to those who did not attend the programme?	Identifying students based on their performance has pros and cons. The pros are you are getting the best and you must improve them, but the cons are that you are only focusing on the best what about the rest? Trainer A empowered the teachers, because the teachers had an opportunity to go on certain programmes. Definitely the learners learned and benefited because majority of them got distinctions in Math and Science and most of them were among the top achievers at our schools.
Would you recommend the STEM programme to the other schools in the district?	Yes, I would recommend it because it was beneficial it just left out the other students.
What would you describe as a positive impact of the programme for your students?	They were able to build a career path, closing a gap making sure that they are employable or are able to create employment.
What were the challenged faced by your students during the 3 years in the programme?	There we problems about the tutors. Sometimes it took time to get a good tutor and sometimes they had to study by

	themselves. It taught them independence and to study on their own. Sometimes they just changed tutors.

Source: Researcher's own compilation, 2019

Based on the responses provided in Table 4.12, Ms Principal A believed that the programme was beneficial because the learners who were on the programme were among the top achievers in the school for the 2018 academic year. She also believed that her teachers also benefited from the programme because there was information sharing with the tutors from Trainer A which enriched her teachers' experience. Despite her positive feeling about the programme, Ms Principal A also felt that having a programme focused only on Mathematics and Science left out good students who were not strong in Maths and Science. Her view was that Maths and Science should not be the only competencies that Company X looks to develop in underprivileged environments. Ms Principal A also believed that the focus on the strong student meant that those who were not strong had no one to help them improve their marks.

Ms Principal A believed that this programme could have been run by the school itself and did not need a company like Trainer A to facilitate. When asked about the challenges she pointed out that there were times that there were no tutors or Trainer A changed tutors; this caused problems with the students who were either left to study by themselves or had to get used to a new tutor and their style of teaching. Overall, she was positive about the programme and said she would recommend that it continues but needed to be implemented at a larger scale encompassing other subjects.

4.3.4 Findings relating to the interview with Principal B

Principal B shared that in 2018 he had a Grade 12 pass rate of 90,7% (with 264 learners) and some of his learners who were on the programme had the highest marks in the entire area. This was a great improvement as opposed to the previous year in 2017 when his grade 12 pass rate was 83.14% (with 301 learners in the grade 12 class). Mr Principal of BB secondary school's responses are laid out in Table 4.13 below.

Table 4.13: Findings relating to the interview with Principal B: the Headmaster

Questions	Response
What is your opinion of the STEM programme?	It is a good programme that assists learners in Key/Risk Subjects. Maths and Science are regarded as difficult subjects. The programme is removing that perception, although the number that the programme is low (only 10 learners).
Did the programme prove to be beneficial to your students who participated as compared to those who did not attend the programme?	The programme benefited the learners' lot, they improved a lot in their subjects, gained more confidence. All of them who participated in the programme performed well in the subjects and they are enrolled in tertiary institutions.
Would you recommend the STEM programme to the other schools in the district?	Definitely.
What would you describe as a positive impact of the programme for your students?	Increase confidence in them (Makes them believe in themselves), Increase performance in their subjects.
What were the challenged faced by your students during the 3 years in the programme?	Some learners lack of parental involvement or support, some do not have parents and come from child headed homes. This makes it difficult for the learners to focus on the programme when they have bigger social issues to deal with.

Source: Researcher's own compilation, 2019

Based on the responses in Table 4.1, Principal B found value in the STEM programme albeit for a small group of students. He saw an increase in confidence from the learners on the programme and an improvement in their performance. He cited lack of parental support as a challenge for children who were on the programme. He also mentioned a challenge that was brought up earlier by the Programme Manager of child-headed households as being a challenge for some of the participants.

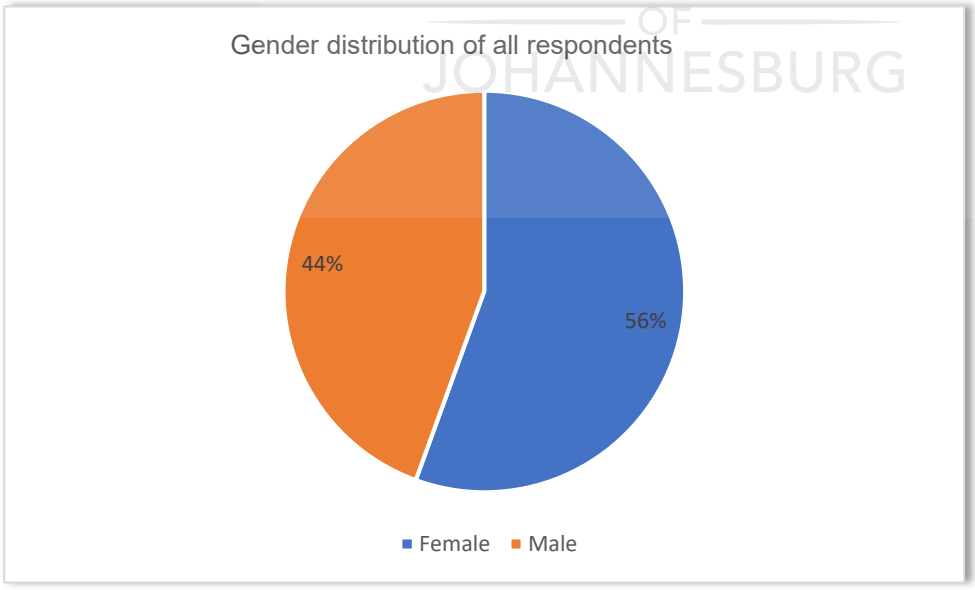
4.4 INTERPRETATION OF RESULTS

The interpretation of the results was derived from the data collected from the semi-structured interviews with the participants. The interpretation was done by analysing the responses provided by the students, Programme Manager and the school principals. In this section, the interview questions were clustered into themes and then interpreted by the researcher.

4.4.1 Results relating to the profile of the participants

56% of the participants were female and 44% were male as shown in Figure 4.2 below. All the participants were African black by race. As explained earlier in the research, the STEM programme was run in a black township in Johannesburg, which would explain the race of all the participants being black as well as the aim of the programme which was to focus on increasing the number of the students from previously disadvantaged backgrounds to qualify to study STEM-related courses in engineering and science disciplines at universities.

Figure 5.1: Gender distribution for all participants



Source: Researcher's own compilation, 2019

4.4.2 Results relating to the value of the STEM intervention programme

Based on their responses, all the participants saw value in the STEM intervention programme that was offered by Company X through the Trainer A as a service provider. The collective view from the students was that the programme contributed immensely in their success in Maths, Science and even English, which was offered as an extra subject for these learners. The students believed that being on the programme gave them an advantage over the other students who were not in the programme. They cited the below reasons for their success:

- The repetition of the work that they were being taught in class, over the weekends was beneficial;
- The resources that were provided by Trainer A such as question papers that they could use for studying purposes put them at an advantageous position; and
- Some students felt that the teaching methods by the Saturday class tutors were better than those used by some of their teachers.

Some students believed that just being chosen to be part of the programme motivated them to work harder and do better. “As I said before, I was not that serious with my schoolwork. When I was attending there, they wanted me to get a minimum of 70% for matric and they also say that they would not take all of us for the bursary for University, so we had to compete” (Computer Science Student). The students mentioned that they fell in love with Maths and Science as a result of the programme and that the programme changed their lives for the better. By analysing their responses, the students saw value in the STEM programme that was provided by Company X.

The Programme Manager, Mr Trainer believed that the programme was a success as they met all the requirements that were put forward by Company X and all the students who were on the programme between 2016 and 2018 passed Maths and Science in 2018 as they completed their matric.

Both the Headmaster and the Headmistress agreed that there was value in the programme based on the results of the students who were on the programme. They mentioned that the students who were part of the programme were among the top achievers in the area and that being in the programme gave these students some sense of confidence. They also saw value in that the students learned to work together as a team to succeed and in that their teachers who were invited to conferences by Trainer A benefitted from sharing the teaching methods and resources.

4.4.3 Results relating to the influence of the STEM programme towards the Sciences

This question was meant to determine if the programme influenced any of the learners or motivated them to choose a career in Engineering or the Sciences. The researcher directed this question only to the students. The responses collected showed that 55% of the participants believed that they had chosen their current career paths because of the STEM programme; that either they learned of the chosen career while on the programme through the lectures or the added career section that happened once a month after the Saturday classes. The participants whose career choices were influenced by the programme were all females. The group explained that added to the Saturday classes was a career guidance section that was ran as X Careers that helped to expose the learners to careers that they did not know existed before. This part of the programme helped the learners prepare for university and exposed them to careers that they did not know existed.

However, 44% of the participants explained that they always knew what they wanted to do prior to joining the programme. This group was made up of the male participants.

4.4.4 Results relating to challenges faced while on the STEM intervention programme

All the participants cited different types of challenges that they experienced during their time on the programme. For the students, the challenges were about the changing of tutors in the middle of the year and being introduced to new tutors that they could not immediately connect with. As much as this was a challenge for some, it was an advantage for others who were excited with

the introduction of the new tutor and believed that their success should be credited to the new tutor. This challenge was highlighted by Ms Principal A as well; her view was that the change in tutors and the time it sometimes took to find tutors was disruptive to the learners' progress.

Some of the challenges mentioned highlight the social challenges that the learners were dealing with at school. These included teenage pregnancy, lack of parental support and children who came from child-headed household and could not sustain being in the programme. The fact that the programme only accommodated 20 students was a problem to the Principals who had hoped that this programme could have a broader reach than just 10 students a school in an environment where a grade 12 class can have as many as 300 learners.

The programme manager had a list of challenges managing the programme, which included stakeholder engagement, namely managing the expectations of the project sponsor and maintaining a good relationship with the schools when they entered grade 12 year as there was competition for the learners between the programme and the schools. Mr Trainer explained that sponsors who are not involved in education do not understand how the system works and have expectations that are sometimes difficult to reach. He explained that most of the learners come with content gap, which means they have a bigger job during the Saturday classes to start by filling the gaps before they could start working on current content. The fact that the programme only focuses on Maths and Science poses a problem in matric because the schools want to focus on all subjects and not just Maths and Science to increase their pass rate for matric. The competition for the learners in the last year meant that the programme started to see more absenteeism of the learners who were scared that they would be penalised for not attending the school programme.

4.4.5 Results relating to the outcome of the STEM intervention programme

Based on the responses provided by the students, Programme Manager and the principals, the general view was that the programme was a success. The students' view was that the programme was a success and they would all recommend it to others. All the students interviewed believed that their success in matric can be attributed to them being part of the

programme. In addition, all the student participants met the programme requirements that were stipulated by with the Trainer A and Company X, which was to pass Maths, Science and English with a 70% pass mark at the end of matric.

When asked whether he believed that the programme was a success, the Programme Manager's response was that "without a shadow of a doubt, we met all our objectives". The principals of both schools concurred with the view that the programme was a success and they would recommend it to others because it was beneficial as evidenced by their matric results for 2018.

Based on the above responses and the results shared in both Table 4.10 and Table 4.11, the programme exuded a positive outcome in that it eventually achieved what it was meant to achieve, namely preparing students from the previously disadvantaged backgrounds to enter STEM-related studies in the engineering and science disciplines at universities.

4.5 Summary

This chapter focused on interpretation of the results of the interviews which were conducted with the programme participants, namely the students, the Programme Manager from Trainer A (the service provider) and the two principals from the participating schools. The chapter presented and interpreted their responses to the various questions put forward by the researcher. The next chapter, which is the final one, serves to conclude the research study in relation to the STEM high school intervention programme. The chapter also proposes a set of recommendations relating to further study in similar topic as well as the implementation of the STEM intervention programme.

The qualitative one-on-one interviews with the participants on STEM intervention programme helped to increase the researcher's understanding on the effectiveness of the programme. Interviews were held with the three groups of people who played crucial roles in the programme. These were:

(a) The 6 learners who participated in and successfully completed the programme, thus managing to enrol for STEM-related studies in engineering and science disciplines at universities field of study;
(b) The Programme Manager from Trainer A (service provider hired by Company X); and
(c) The Principals of two participating schools from the township, east of Johannesburg.

Due to the unfortunate occurrence of the global pandemic of Covid-19, the researcher was unable to have face-to-face interviews with the Principals but used Skype to conduct the interviews.

The interviews from the participants were analysed against the background of past research in literature in order to find common themes in search of an answer to the primary and secondary research objectives. The responses from the students were also analysed to find commonality to the research questions and a summary of the responses was provided by the researcher. The same approach was used for the Principals (Headmaster and Headmistress). Finally, the Programme Manager's questions were also analysed in pursuit of the answers to primary and secondary research objectives.

5.1 INTRODUCTION

Presentation of the interview data and the interpretation thereof was dealt with in the previous chapter. In this chapter the research objectives are appraised in connection with the findings of the empirical study and the literature reviewed so that it can be concluded whether these objectives have been met or not. Finally, based on the findings and the results of the empirical study and the literature review, recommendations are made with regards to how the programme can be improved and what related areas of study can be given attention by other researchers.

5.2 CONCLUSIONS

The aim of this study was to evaluate the effectiveness of the STEM intervention programme in preparing students from previously disadvantaged backgrounds to further their education in STEM-related studies in engineering and science disciplines at universities. The study sought to achieve the above aim by drawing a parallel between the STEM high school intervention programme and the results that were achieved by the learners at the end of their matric year. The study was conducted through an critical review of literature as well as by conducting the interviews with participants who solely comprised the learner and two Principals from two high schools located in a black township, east of Johannesburg, as well as the Programme Manager from Trainer A, which is the service provider employed by Company X for the purpose of implementing the programme at the said schools. The researcher wanted to understand if there was any value in Company X's efforts at investing in the STEM intervention programme by evaluating the effectiveness of the programme in preparing the students to further their education in STEM-related studies in engineering and science disciplines at universities.

The school principals were generally happy with the programme, but both expressed disappointment that the programme only sponsored a small group in their schools. When the

head of school has 264 learners in a grade 12 class, it explains why Mr Principal B would be disappointment that the programme only touched a small part of the grade. 254 grade 12 students were left out of the programme because only 10 students from School BB were part of the programme in 2018. Essentially only 4% of his grade 12 class was part of this programme and benefited from the programme in an area where more students would have benefited to be part of such a programme.

It is the researcher's opinion based on the information that has been provided, that the Trainer A Programme Manager faced challenges, the most difficult of which was dealing with the content gap that the students came with as a result of the structural requirements of the South African Education system. These gaps move along with the students who have not passed a grade, which mean that some of the students joined the programme with foundational issues.

5.2.1 Conclusion relating to the primary research objective

The primary research objective was to evaluate the effectiveness of STEM intervention programme in preparing high school students for STEM-related studies in engineering and science disciplines at universities. From the findings of this study, it was concluded that, as presented in Chapter 4, it was concluded that STEM intervention programme achieved an overall measurable success in preparing the students from previously disadvantaged backgrounds for STEM-related studies in engineering and science disciplines at universities. However, challenges were also identified with regards to the implementation of the STEM programme, such as the socio-economic conditions of the learners that contributed to some dropouts and the fact that the programme only impacted a small number of the learners in the two schools. Alongside the issue of stakeholder management, the content gap was also one of the challenges that were identified.

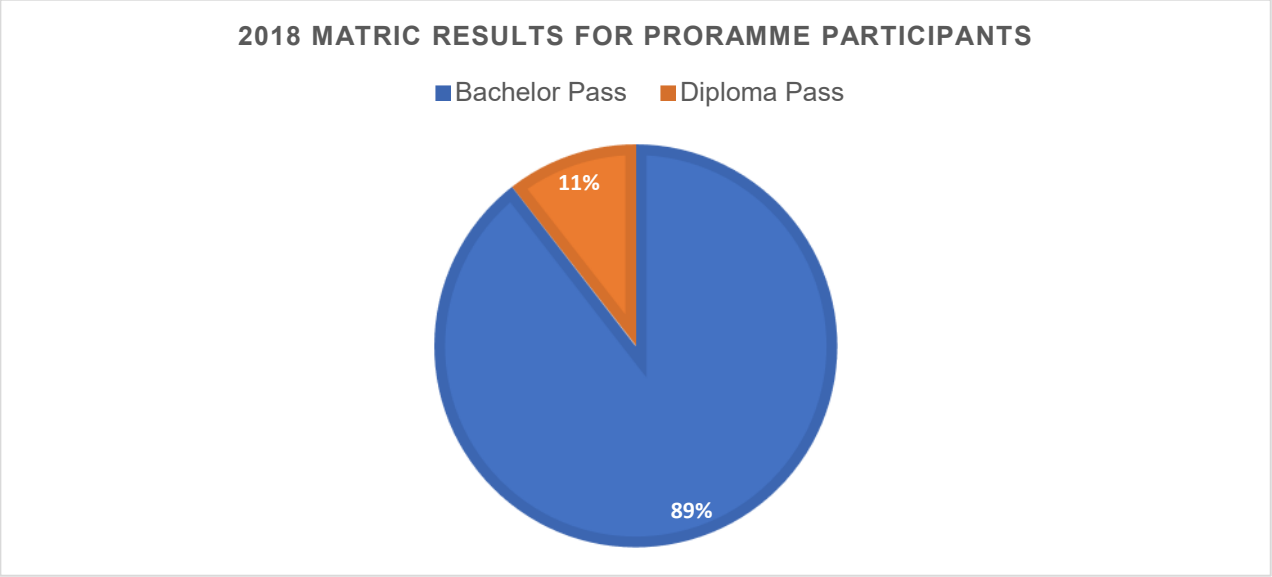
The STEM programme was effective and, as a result, influenced the students' choice to register for STEM-related engineering studies. Those that did not choose Engineering chose Sciences that are related to the STEM. 50% of the students who did not select Engineering as a career selected choices that required them to have excelled in Maths and Science. Examining the entry

requirements for a bachelor's degree in medicine at a reputable university in Johannesburg, a matriculant applying for Medicine must have passed English, Maths and Physical Science with a level 5 pass. A level 5 pass is (60%-69%), which is considered a substantial achievement. The 19-year-old female student who is currently studying Medicine and was one of the participants, received 4 distinctions, 70% for English, 83% for Maths and 80% for Physical Science. When asked if she believed that the programme contributed to her overall success, her response was: "Yes, Maths results were better than I could have expected. Got a distinction in Maths. There was more engagement on Saturdays. English was quite helpful; on Saturdays they did more the basics of how to construct a sentence".

For the three students who chose engineering as a career, all responded that being in the programme contributed to their overall success in matric and added that without the programme they could not have reached the level of success that they reached, including achieving the distinctions that they obtained. It is thus the researcher's view that the STEM programme was a successful tool to prepare the learners to successfully enter a career in Engineering and other STEM-related careers.

All the students who were part of the programme achieved matric pass in 2018. Out of the 20 learners who entered the programme, there was 1 drop out; meaning that the programme ended with only 19 participants. 17 learners received a Bachelor pass in matric. As illustrated in figure 5.1 below, 89% of the programme participants were eligible for a spot in university. It is important to point out that the researcher only interviewed 32% of the programme participants and all of the interviewed participants had achieved high marks in Maths and Science. The participants all explained that the programme had shaped their attitude towards Maths and Science; some even mentioned that the programme made them "fall in love with Maths".

Figure 5.2: 2018 Programme Participants' Matric Results



Source: Researcher's own compilation, 2019

With the figures presented in Figure 5.1, the researcher surmises that the programme was an overall success. However such success was achieved with challenges, which were shared by the students, Trainer A, Programme Manager and the Headmasters as described in Chapter 5 above.

5.2.2 Conclusions relating to secondary research objectives

The secondary research objectives arising from secondary questions of this study were:

- To clarify the concept of STEM intervention programme;
- To determine possible challenges relating to the implementation of STEM intervention programmes in high schools;
- To determine the relevance of STEM programme in creating engineers and scientists;
- To propose recommendations for future research and the strategies for successfully implementing STEM intervention programmes in high schools.

a) Conclusion relating to secondary research objective 1

With reference to clarifying the concept of STEM intervention programme, the concept was described as a Science, Technology, Engineering and Mathematics (STEM) programme that is aimed at enhancing the learners' performance in STEM-related subjects with a view to opening up opportunities for them to further their education in STEM studies in engineering and science disciplines at universities.

b) Conclusion *relating to secondary research objective 2:*

The secondary research objective sought to determine possible challenges relating to the implementation of STEM intervention programmes in high schools. The following is a summary of the challenges that were highlighted:

Challenges for the Students:

(i) the changing of tutors in the middle of the year;
(ii) being introduced to new tutors that they could not immediately connect with;
(iii) having to work even harder in order to meet the expectations of the sponsor; and
(iv) dividing their time between attending the STEM programme and their respective school programmes.

Challenges for the School Principals:

(i) having to fill the content gaps and satisfy the STEM programme sponsors at the same time;
(ii) competing with the programme managers for the students' time due to the demands of their parallel school programmes;
(iii) dealing with the fact that the programme only accommodated a limited number of learners;
(iv) dealing with the fact that the programme only focused on Maths and Science whereas the school wanted to focus on all subjects to increase the students' chances of pass at matric.

Challenges for the Programme Manager:

(i) the change in tutors and the time it sometimes took to find tutors was disruptive to the learners' progress;
(ii) managing the programme, which included the following:
    - stakeholder engagement;

- managing the expectations of the project sponsor;
- maintaining a good relationship with the schools despite having to compete for the learners' time with the schools;

(iii) The threat of absenteeism and/or drop-out as a result of any of the following factors:

- Teenage pregnancies;
- Lack of parental support;
- Dealing with the learners coming from child-headed households.

c) Conclusion relating to research objective 3:

With regards to the objective of determining the relevance of STEM programme in creating engineers and scientists, it was concluded that this objective was met as 50% of the students who participated in the STEM high school intervention programme of this research were accepted for engineering in different disciplines in universities. Two of the students interviewed chose a career in Engineering because of the programme and the type of exposure that they found in the programme. One student claimed that he always knew that he wanted to be an engineer, however his dreams were realised by being in the programme: "it was always my dream to do what I am doing" - Aeronautical Engineering student. Through this programme, the students learned about STEM-related careers that they were not aware of before joining the programme.

The remaining 50% had chosen career in science-related fields. One student was accepted for Bachelor of Computer Science, another for Bachelor of Medicine and Surgery, and the last one was accepted for the degree of Bachelor of Science in Speech and Language Pathology.

The researcher concludes that the STEM intervention programme was effective in preparing the students for STEM-related studies in engineering and science disciplines at universities because the learners' view was that the programme positively influenced them to love Maths and Science. These students had a fair chance of competing for a place at university with students from all other backgrounds. The programme also played a major part in improving the student's final matric marks, thus providing an opportunity for the students to choose STEM-related careers at university.

d) Conclusion relating to secondary research objective 4:

The conclusions relating to the secondary research objective 4 are directly transferrable to the recommendations that are discussed in section 5.3 below, because this objective sought to propose recommendations for future research and the strategies for successfully implementing STEM intervention programmes in high schools.

5.3 RECOMMENDATIONS RELATING TO FINDINGS OF THE STUDY

As stated in section 5.2.2 (d) above, the recommendations provided in this part of the study are directly transferred from the conclusion relating to secondary research objective 4, which was aimed at proposing recommendations for future research and strategies for successfully implementing STEM intervention programmes in high schools.

a) Recommendations for STEM intervention programme implementation strategies

The challenge regarding the tutors and the change of tutors is one that is more difficult to deal with. A programme that is run over a period of 3 years cannot guarantee that the people who were employed when it started will be the same at the end of the programme due to different personal circumstances and changes in those people's lives. All that can be recommended is that Trainer A needs to make sure that the level of standard of their delivery remains constant even with the change of tutors. What this means is ensuring that there should be standard requirements for the tutors that they employ with regards to qualification, education and experience. What will differ will be the tutors' style of delivery, but the standard should remain the same. In the case of the change that was made by Trainer A, it is the researcher's belief that the standard was retained, as one of the students believe that her improvement and distinction was as a result of the new tutor. Suffice it to say that the choice of tutor is a subjective matter.

It is the researcher's recommendation that this programme should be started earlier than grade 10. The programme needs to be an intervention programme from foundation phase; in this way, there would not be content gaps when the students chose their core subjects at grade 10. This will also shape the learner's understanding and love for the subjects that are most feared in our schools, namely the STEM-related subjects such as Maths and Science. "The early years of

one's life are an important phase for promoting cognitive development and the acquisition of foundational Knowledge and skills. “Many poor children fail to reach their potential cognitive development because of deficiencies in their early development” (Reddy et al; 2012:89). If Programme Managers like Trainer A work hand-in-hand with the teachers to help develop the fundamentals for the subjects, it is the researcher’s opinion that this will increase the number of learners who consider STEM subjects.

It is also the researcher’s recommendation that Company X ought to consider increasing the number of students they take into such a programme. In this case, it is recommended that the number of learners selected ought to be relative to the numbers of learners in that particular school. The pilot has proven to be successful and Company X can confidently increase its CSR contribution to such a programme as part of it pipeline development programme as well as benefiting the community that it operates in.

It is also recommended that when the students successfully enter the university, sponsors like Company X should play a bigger role than just being the financier. The students need on-going support as they enter tertiary institutions. Some students felt neglected when they entered university, because they had been nurtured as they formed part of a special group for 3 years. However, suddenly, they found themselves thrown headfirst into a different world without the same support structures, unable to efficiently navigate their way through the maze of tertiary life and its unusual demands. It is therefore the researcher’s recommendation that the life skills and career programme that was part of Trainer A’s programme should continue into the first year of university to help the students to settle socially as well as psychologically into the new world.

b) Recommendations for future study

The sample used was small for the research to conclude that this programme would yield the same result with a bigger sample of programme participants. An expanded research with a larger number of learners who have been part of this or similar STEM programme is recommended. This would provide a better insight into the benefits that the STEM intervention programme can bring to a wider spectrum of our education system in underprivileged areas that are similar to the Township X.

Another area of further research would be to conduct a quantitative research to evaluate the numbers of students from previously disadvantaged background who, even without such a programme, successfully enter the engineering and science fields at universities compared to those students who successfully qualify to study in the engineering and science fields after having been part of a similar programme to that which was evaluated in this research.

6.1 SUMMARY

This research was concluded during the time in history when South Africa, which has just been downgraded into junk status, was in a lockdown due to the pandemic of Covid-19. The world economic stability was in question; there were fears that jobs would be lost after the lockdown as companies struggle to make ends meet. This was likely to increase the already high unemployment rates in the country. It is the researcher's opinion that occupations that are in high demand are what we need to focus on as a country in order to ensure that the students coming out of university are employable and relevant the economic needs of the day. This means that we all have a role to play in encouraging learners towards STEM-related subjects in preparation for the 4th Industrial revolution which is coming hard and fast as Covid-19 has forced us to rely heavily on technology to connect and continue with our daily jobs.

The STEM programme run by Trainer A for Company X was a success and many such programmes should be introduced in our public schools to help the already overloaded schooling system. The overloaded schooling system results in teachers leaving some learners behind because they cannot give personal attention to each and every one of the students due to the huge numbers they are handling per class on a daily basis.

The fact that Company X would pay for their university fees, and they did not have to worry about tuitions, accommodation, books and food made it possible for them to concentrate on what is important. Succeeding in their schoolwork was indicated by all students from the STEM intervention programme as a huge benefit.

APPENDIX 1

UNIVERSITY OF JOHANNESBURG

DEPARTMENT OF BUSINESS MANAGEMENT RESEARCH ETHICS COMMITTE

Dear S. Nene

ETHICAL APPROVAL GRANTED FOR RESEARCH PROJECT

Decision: Clearance granted

This letter serves to confirm that that the proposed research project indicated in the table below, has been reviewed by the Department of Business Management Research Ethics Committee at the University of Johannesburg. Ethical clearance is granted for 1 year, from September 2019 to September 2020.

Applicant	S. Nene
Supervisor	Dr. P. Thomas
Student/staff number	200584467
Title	The value of STEM high school intervention programmes
Decision date at meeting	5 September 2019
Reviewers	Dr Makka, Dr Schachetebeck, Dr Boikanyo and Dr Kalitanyi
Ethical clearance code	2019BM56
Rating of application	CODE 01

CODE 01 - Approved
CODE 02 - Approved with suggestions without re-submission
CODE 03 - Referred back
CODE 04 - Disapproved, cannot re-submit

The researcher/s may now commence with the study providing that:

1. The researcher/s will ensure that the project adheres to ethical research requirements
2. The researcher/s will be conducting the study as set out in the approval application
3. The researcher/s will ensure that project adheres to all applicable legislation, scopes of practice, professional codes of conduct and scientific standards as it pertains to the field or study.
4. The researcher/s will bring under the attention of the research ethics committee any proposed changes, concerns that arise, and unexpected ethical management issues

5. Any changes that can affect the study-related risks for participants or researchers must be reported to the committee in writing
6. All relevant permission required to access data, organisations, etc. has been obtained.
7. No fieldwork activities may continue after the ethical clearance has expired. A request for an extension of ethical clearance can be made in writing to the REC

If research is to be conducted among UJ staff of students, permission is required from the Registrar's Office or Corporate Governance, before the study can commence.

Signature:

Name of Chairperson: Dr A. Makka

Name of Committee: BMREC

Email: amakka@uj.ac.za / pthomas@uj.ac.za

Telephone: 011 559 2074 / 011 559 1325

Research Question	Questions in questionnaire for students
a) To evaluate the effectiveness of the STEM interventions in preparing students for the engineering discipline in a reputable university	How often did you attend the extra STEM lessons?
	Do you believe that being in the programme gave you and advantage over the other students who were not on the programme?
	In your opinion did the STEM programme contributed to your overall success in Mathematics and Science in your final matric results?
	How did the STEM programme shape your attitude towards Mathematics and Science in the 3 years that you were in the programme?
	How has being in the programme prepared you for your tertiary education in your chosen field?
	Do you believe that being in the programme influenced you in choosing a career in the Engineering or the Science field?
b)	Did you meet all the requirements of the STEM programme
c)	Would you recommend the STEM programme to other students interested in the engineering field
Research Question	**Questions in questionnaire for Headmasters**
b) Is there value of STEM high school intervention programme	What is your opinion on STEM programmes
	Did the program prove beneficial to students who participated as compared to those who did not attend the programme?
	Would you recommend the STEM programme to other schools in the district?
	What would you describe as the positive impact of the programme for your students?
	What were the challenges that your students faced during the 3 years of the programme in relation to the programme?
	Questions in questionnaire for Protec Programme Manager

	Based on the objectives set up by Company X at the beginning of the programme in 2016, do you believe that this programme was a success and met all the objectives
	Do you believe that STEM intervention programmes should be started in high schools or earlier for students in the public-school systems to encourage an increase in students who choose Mathematics and Science
	Please share some of the challenges you were faced with during this 3-year programme
	Were the initial 20 students the same students that graduated from the programme. If there were any dropouts, can you share what the reasons were for the dropouts
	How did you maintain an alignment between the programme curriculum and what the students were struggling with in the classroom
	What could have been done differently in this programme to ensure success for the students
	What was Training Company A's relationship with the teachers, headmasters and the schools district officer

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