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AN ASSESSMENT OF THE CURRENT LEVELS OF ENGINEERING SKILLS’ SHORTAGES IN THE SOUTH AFRICAN CONSTRUCTION INDUSTRY

by

MOYAHABO PRUDENCE MAAKE

A DISSERTATION

submitted in fulfilment of the requirements for the degree MAGISTER TECHNOLOGIAE in

CONSTRUCTION MANAGEMENT

in the

FACULTY OF ENGINEERING AND THE BUILT ENVIRONMENT

at the

UNIVERSITY OF JOHANNESBURG

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CO-SUPERVISOR: PROF. W.D. THWALA
FACTORS RESPONSIBLE FOR THE ENGINEERING SKILLS’ SHORTAGES IN SOUTH AFRICAN CONSTRUCTION INDUSTRY

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JOHANNESBURG, FEBRUARY 2016
DECLARATION

I, MOYAHABO PRUDENCE MAAKE, do hereby declare that this dissertation is the result of my own investigation and research, except to the extent indicated in the references and by comments included in the body of the report and that it has not been presented elsewhere for a similar purpose. It was submitted to the University of Johannesburg (Department of Quantity Surveying and Construction Management), as a requirement to obtain a MAGISTER TECHNOLOGIAE degree in Construction Management.

Signature

Date

University of Johannesburg,

Doornfontein Campus
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My gratitude to the Almighty God for guiding me this far in life. Without Him I would have not been able to do anything. I am also grateful to Him for granting me the strength to carry out this research study.

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- My family for their support and encouragement (Lillian Maake, Lazarus Chikane, Itumeleng Chikane, Gontse Maake).
- My friend Keitumetse Tserema for the support and the encouragement to always work hard and not to quit; and
- Finally, I would like to express my profound gratitude to the Department of Construction Management and Quantity Surveying, University of Johannesburg, South Africa for their valuable support to study with them.
DEDICATION

I dedicate this Dissertation to my parents, Lillian Maake and Lazarus Chikane.
The construction industry is regarded as one of the key sectors in the development and economic growth of South Africa. However, the industry faces the challenges of engineering skills’ shortages. The objectives of this research were to explore the engineering skills’ shortages in the South African construction industry with a view to understand what causes these shortages. Understanding the effects could enhance the success of minimising the challenges of skills shortages that the construction industry is facing.

Data used was derived from related literature and a collection of questionnaire distributed to professionals in the construction industry. Findings revealed that there is a shortage of engineering skills. The level of supply of these shortages is attributed to the lack of retirement of experienced engineers; the low pass rate in science, Technology, Engineering and Mathematics (STEM) subjects, poor career guidance in subject choices; lack of experiential training opportunities; lack of mentors for new graduates; lack of government support for tertiary education; immigration of experienced engineers, low remuneration of engineering professionals, and the growth of new industries in different regions with different skills’ bases were the major causes of the engineering skill’s shortages in the construction industry. Additionally, based on the findings difficulties in recruiting; poor decision making due to not having the right skilled people; lack of quality relevance of training received were amongst the major effects of the engineering skills’ shortages to the construction industry. A key point is that the industry would benefit from the use of retired experienced engineers for mentoring programs, higher remuneration scales for engineering professionals, and employers collaborating with educators to identify the skills’ needed to map career pathways amongst others to minimise the engineering skills’ shortages in the construction industry. It is recommended that the construction industry, as well as secondary and higher education institutions, should be made aware of the factors that cause engineering skills’ shortages and ways to minimise these shortages in the construction industry.

Key words: Engineering, skills’, shortages, construction industry, Gauteng Province, South Africa.
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LIST OF ABBREVIATIONS

ANC – African National Congress

ANET – Australian National Engineering Taskforce

AsgiSA – Accelerated and Shared Growth Initiative for South Africa

BCA – Business Council of Australia

CDE – Centre for Development and Enterprise

CPI - Consumer price index

DEEWR – Department of Education, Employment and Workplace Relations

DIISTR – Department of Innovation, Industry, Science and Research

E&C – Engineering and construction

EEHC – Egyptian Electricity Holding Company

EITI – Extractive Industries Transparency Initiative

ESS – Employers’ Skills’ Survey

GDP – Gross domestic product

GFC – Global financial crisis

GST – Goods and Services Tax

GVA – Gross value added

GW - Gigawatts

HESA – Higher Education South Africa

ICT – Information Communication Technology
IET - Institute of Engineering and Technology

JIPSA – Joint Initiative for Priority Skills’ Acquisition

KET – Key enabling technology

MIS – Mean item score

NSC – National Senior Certificate

OECD – Organisation of Economic Co-operation and Development

PICC – Presidential Infrastructure Coordinating Commission

SADTU – South African Democratic Teachers’ Union

SAGDA – South African Graduate Development Association

SD – Standard deviation

SETA – Sector Education and Training Authority

STEM – Science, Technology, Engineering and Mathematics

WEF – World Economic Forum
CHAPTER ONE

1. INTRODUCTION

1.1 BACKGROUND

Engineering skills’ shortages interacts with almost all spheres of human aspects. It also has a very strong link with other sectors of the economy other than construction sector.

The literature review and the supporting theory will identify the major factors responsible for the engineering skills’ shortages in South Africa. This research will concentrate on a specific group of knowledge professionals which are in short supply in the construction industry

1.1.1 Construction Industry

The construction industry has unique characteristics that distinguish it from other sectors in the economy (Thwala & Mofokeng, 2012). The construction industry is very important in our everyday lives because of the outputs and outcomes of its activities. It is the nation’s economic backbone as it forms the arteries for the facilitation of productive activity by enabling goods and services to be distributed outside and within the country. It provides the buildings which are used in the production of all goods in the economy and, the physical structures built through construction activity; therefore it contributes to the national socio-economic development. Studies show that the construction employs up to 10 per cent of the working population, and is responsible for about half of the gross fixed capital formation (Lopes, 2012).

1.1.2 Engineers in the construction industry

Engineers are the people who can create practical solutions to our 21st century challenges of sustainability, housing and an ageing population (Perkins, 2013). Most developed countries are getting involved in massive projects for developing infrastructure and shortages of engineering capacity has been the worst scarce crisis in recent years. Most employers around the world find it difficult to recruit critical staff to fill positions in their businesses (Manpowergroup, 2011a). Skills’ shortages pose significant limitations on the economic growth of the country (Sharp, 2011).
1.2 AIM OF THE STUDY

The aim of this study is to identify the factors responsible for the engineering skills’ shortages in the South African construction industry. The second aim of the research is to further add to the knowledge base on the effects that engineering skills’ shortages have on the South African constructing industry. This study also investigates measures of minimising engineering skills’ shortages in the South African construction industry.

1.3 PROBLEM STATEMENT

Engineering skill’s shortages has been an ongoing issue ever since the advent of democracy in 1994. Despite the number of education reforms, the country is still facing considerable shortages in the construction industry. According to Bhorat, Meyer and Mlatsheni (2002) and Kraak (2008), the engineering skills’ shortage is one of the major drawback for the progression of the country. South Africa has only 45 engineers per million people, while the United State of America (USA) has 380 engineers per million people, China and India have 95 per million people (Engineering Council of South Africa, 2007). The South African economy is taking tremendous strain as the construction industry is in dire need of engineers, quantity surveyors, technicians and architects. Inadequacies in the present education system regarding mathematics and science are definitely not going to increase the intake of engineering students (Rasool & Botha 2011). In addition to the situation, the sector education and training authority (SETA) has also not made a sufficient contribution to addressing the engineering skills’ shortages (Mackenzie, 2008). The labour market in South Africa is characterised by a large number of unemployed people, including graduates (Kraak 2008; Bisekar & Paton, 2005).

Most of the students enrolling at universities usually end up not completing their degrees and the supply of skills is also flattened out (Department of Education, 2005). This dissertation examines the current situation regarding the engineering skills’ shortages in South Africa and suggests means to mitigate these shortages. It focuses on the factors affecting the engineering skills’ shortages in the construction industry. According to Du Toit and Roodt (2011) factors such as status and engineering professions in relation to other more lucrative careers, the shortage of matriculants who meet the criteria to gain entrance to the engineering degree programme, and the high quality of engineering education in the country are factors contributing to our crisis of engineering skills’ shortages and ironically makes our graduates in great demand internationally.
1.4. RESEARCH QUESTIONS

The study aims to provide answers to the following research questions:

1. What are the causes of the engineering skills’ shortages in the South African construction industry?
2. To what effects do the engineering skills’ shortages have on the South African construction industry?
3. What measures can be taken to minimise the engineering skills’ shortages in the South African construction industry?

1.5 RESEARCH OBJECTIVES

The major objectives of this study can be highlighted as follows:

1. To determine the causes of the engineering skills’ shortages in the South African construction industry;
2. To analyse the effects of engineering skills’ shortages on the South African construction industry; and
3. To establish measures of minimising the engineering skills’ shortages in the South African construction industry.

1.6 MOTIVATION FOR THE STUDY

The motivation for conducting this research was to improve the knowledge base regarding the factors responsible for the engineering skills’ shortages in the South African construction industry. The results of this study will hopefully contribute towards a better understanding of the causes, effects and measures of minimising engineering skills’ shortages. Furthermore, this study will help in understanding the different/various factors that are responsible for engineering skills’ shortages in the construction industry.

1.7 PURPOSE OF THE STUDY

The study examines previous literature on engineering skills’ shortages, with the specific aim of identifying the factors that play a dominant role in the engineering skills’ shortages. The concept of skills’ shortages has been attracting much attention in recent years and researchers
and research bodies, be they private or government, try to develop measures to minimise the crisis with an understanding of the factors responsible for the engineering skills’ shortages.

1.8 RESEARCH METHODOLOGY AND DESIGN

1.8.1 Research Methodology

Research methodology explains the method used in conducting out the research. This section outlines the geographical area where the research was conducted, the study design and the population sample. The instruments utilised in collecting data and methods implemented to maintain validity and reliability of the instruments are also described.

1.8.2 Research approach and design

A quantitative approach was adopted in this research. A descriptive survey design was also adopted in the conduct of the study, thus, designing of a questionnaire and distributing them was the method used to obtain information relating the current study.

1.8.3 Research area and targeted respondents

This study was carried out in Gauteng Province of South Africa, targeting construction professionals in the area who are currently working or have worked on completed or on-going construction projects. The target population of this research were architects, quantity surveyors, civil engineers, construction managers, construction project managers, project managers and other professionals who are involved in construction projects in Gauteng Province, South Africa.

1.8.4 Sampling and data collection

This study adopted a random sampling method; hence all the participants had an equal chance of being selected. A questionnaire was developed as a tool of collecting data from the respondents in accordance with the reviewed literature.

1.8.5 Delimitations

This research assessment was on construction professionals in Gauteng Province in South Africa, with the respondents being architects, quantity surveyors, civil engineers, construction managers, construction project managers, project managers and other professionals who are
involved in construction projects in the province. This study determines the factors responsible for the engineering skills’ shortages in the construction industry. In addition, it establishes the measures that will be employed to minimise engineering skills’ shortages in the construction industry in Gauteng Province, South Africa.

1.8.6 Ethical considerations

The current study did not encounter or identify any ethical issues. However, the ethical considerations in this research involved acknowledging professionals in the industry whose work had been cited and who have therefore contributed to the literature. The obligation to the participants who responded to the research questionnaire, was that their input would be kept confidential and only used for academic purposes. Respondents to the questionnaire had the right not to answer questions that they felt were not appropriate without any coercion.

1.9 OVERVIEW OF CHAPTERS

The study consists of nine chapters: the introductory chapter, overview of engineering skills’ shortage in the construction industry, engineering skills’ shortage international overview, engineering skills’ shortage in Nigeria and Egypt, engineering skills’ shortage in South Africa, methodology and design of the study, data analysis, discussions of findings, conclusion and recommendations to the study. Chapters more specifically deal with the following:

Chapter one: Introduction

This chapter defines the problem that the researcher aimed to investigate and indicates how the investigation of the problem was conducted. The introduction gives an overview of the problem and the research questions. This chapter-therefore provides a framework of the whole study.

Chapter two: An overview of engineering skill’s shortages in the construction industry.

This chapter reviews literature on the same topic by scholars and researchers. The literature review highlights knowledge and ideas that have been established by other researchers on the topic. Hence this chapter gave the readers an understanding of the causes of the engineering skills’ shortages, the effects thereof and further suggest measures of minimising engineering skills’ shortages in the construction industry.
Chapter 3: Engineering skills’ shortages - International (Canada and Australia)

This chapter provides a background to the study that is being proposed, in terms of work that has been published by other scholars and researchers internationally. The intention is to examine knowledge and ideas of other researchers about what has been studied on the topic internationally.

Chapter four: Engineering skills’ shortages - Africa (Nigeria and Egypt)

This chapter highlights a literature review with reference to past studies relating to Nigeria and Egypt and, historical causes of the engineering skills’ shortage in the construction industry.

Chapter five: Engineering skills’ shortages: South Africa

This chapter explains the background to the study that is being proposed relating to, work that has been published by other scholars and researchers in South Africa with the intent to conceptualise the problem statement and objectives of the study. The literature review includes references to past studies, a brief background on the factors that cause the engineering skills’ shortage in the South African construction industry, and extracts key points by comparing South Africa with studies across other countries.

Chapter six: Research methodology

This chapter indicates the methods that the researcher used to obtain participants and further collect information from these participants. In this study, the researcher focused on a literature review and a questionnaire survey targeted at construction professionals in Gauteng, South Africa. Furthermore, statistical methods used to analyse the data collected from the questionnaire survey are described in this chapter.

Chapter seven: Questionnaire survey results

Once an appropriate design and suitable means of measuring relevant variables had been identified and adopted, the findings were analysed using an appropriate procedure. Statistical techniques were adopted to analyse data and draw up findings. The analysed results then provided feedback with respect to the originally formulated questions.

Chapter eight: Discussion of findings
In Chapter 8 the findings analysed in Chapter 7 are discussed and linked to the literature reviewed in order to establish whether the research objectives were achieved and all the research questions were answered.

Chapter nine: Conclusions and recommendations

This chapter further concludes the study and gives recommendations on how to minimise engineering skills’ shortages in the construction industry.

1.10 CONCLUSION

In this chapter, the various components of the study were introduced. The research problem, rationale, research questions and the structure of the study were discussed. It is against this background that an understanding of the present research was attained. The next chapter provides an overview of the engineering skills’ shortages.
CHAPTER 2

AN OVERVIEW OF ENGINEERING SKILLS’ SHORTAGES IN THE CONSTRUCTION INDUSTRY

2.1 INTRODUCTION

This chapter provides an overview of skills’ shortages; it defines and describes terms and concepts that are used frequently throughout the study. The contents of this chapter assist in the overall understanding of the study as it provides detailed explanations of terms that are crucial to the study as a whole. This chapter further touches on causes of the skills’ shortages and their effects as well as measures to these. It also presents a discussion of skills’ shortages in relation to the engineering sector in the construction industry as the study focuses on the engineering skills’ shortage in the construction industry.

2.2 SKILLS’ SHORTAGES

A shortage of skills’ has been a public persistent theme over the past years. A shortage of skills has long been a feature of economic and social landscape (Department of Labour, 2003). It is becoming very difficult for employers globally to find the skills they need. There seems to be no quick fix solution to the skills’ problems that have developed over a substantial period of time (Department of Labour, 2003). When discussing skills’ shortage one need to take into consideration skills’ as encompassing economic and institutional factors as well as innate abilities and personal characteristics (Malcolm & Mahmood, 2002). For every country’s economic success it is essential to tackle the skills’ shortage and make sure it meets the employers’ skills needs as skills’ shortage is economically damaging (UKCES, 2010). According to Mirchandani (2016), it is becoming more and more difficult globally for young people to advance up the career ladder; the nature of work is forever changing and new technologies are emerging and impacting multiple sectors while employers are also demanding experienced workers with skills’. The ability of candidates to adapt, grow and compete with the kind of workforce that is entering the job market is a huge problem the industry is facing (Mirchandani, 2016). A consideration of what skills’ shortages mean and how they are generated follows:
2.2.1 Meaning of skills

Although there are different meanings attached to the terms ‘skills’, ‘shortage’, ‘skills’ gap’ and ‘recruitment difficulties’, in order to understand each their meanings and how are they related to each other are considered. According to Labour Market Trends (2002), a skill is the ability to perform a task to a predefined level of competence. Skills are often divided into two types: transferable and generic skills, which can be used across large numbers of different occupations, and vocational skills, which are specific occupational or technical skills needed to work within an occupation or occupational group (Labour Market Trends, 2002). Skills’ shortages refer to shortages of relevant suitably skilled people available in the labour market, relative to the jobs that employers are offering (UKCES, 2010).

When there is a high demand for workers for a particular occupation than the supply of workers who are available, qualified and willing to work under existing market condition then a shortage will occur (Shah & Burke, 2003). A long-standing definition that appeals to economists is that by Arrow and Capron (1959: 298-308), namely that a shortage is “… a situation in which there are unfilled vacancies in positions where salaries are the same as those currently being paid to others of the same type and quality.

An alternative definition, expressed in terms of supply and demand, is “… a market disequilibrium between supply and demand in which the quantity of workers demanded exceeds the supply available and willing to work at a particular wage and working conditions at a particular place and point in time’” (Barnow, Trutko & Robert, 1998). Shortages have always been interpreted directly in terms of difficulties in filling vacancies. Shortage exist when employers accept applicants whose skills are not in match with the ideal vacancy, but hence from the market perspective no shortage exist because the positions were filled. Therefore there won’t be any imbalance in the labour market if over qualified people fill the positions (Department of Infrastructure, 2003).

Skills’ gap

A skills’ gap refers to a situation where employers are hiring workers whom they consider under-skilled or their existing workforce is under-skilled relative to some desired level (Shah & Burke, 2003). Employees in many instances may have the necessary and relevant vocational qualification needed to their occupation and lack the generic skills (Department of
Recruitment difficulties

Recruitment difficulties are caused by a shortage of individuals with the required skills’ in the accessible labour market (Labour Market Trends, 2002). Factors such as poor image of the industry, long working hours, incentives and low remunerations, very poor working conditions and ineffective recruitment effort by the firms are some of the reasons we having difficulties in recruiting the right candidates for the job (Shah & Burke, 2003).

2.3 CAUSES OF SKILLS’ SHORTAGES

The skills’ requirements around the world have been affected by rapid globalisation and technological changes. Skills’ shortages are becoming a growing problem for employers and they struggle to find the skills’ they need among the global talent pool (OECD, 1996). Skills’ shortages pose a problem globally (Zieminski, 2009).

Skills’ shortages vary from country to country but many countries have failed to educate their indigenous workforce in a manner that produces the skills’ demanded by the production sectors in the countries concerned (Slay, 2010). Employers are more interested in a specific skills as work is becoming more complex (Zieminski, 2009). There are numerous causes of skills’ shortages and they seem unlikely to be resolved in the near future (Neumark, Johnson & Mejia, 2013). Lack of experience and skills needed by the employers hinder most people who are looking for employment (Zieminski, 2009). The economies of most countries will be impacted by this fact and the demand for highly specialised workers with skills’ (ManpowerGroup, 2011b).

2.4 BUSINESSES THAT EXPERIENCE SKILLS’ SHORTAGES

A national skills list is produced periodically in South Africa, to identify areas of the type of skills’ that requires education and training intervention (Heyns & Luke, 2012). The last available national scarce skills’ list was produced in 2008 (Department of Labour, 2009). The 2006/7 scarce skills’ list (Department of Labour, 2007) identifies engineering and built environment professions, health professions, finance professions, law professions, city planners, IT/ICT professions, natural science professions, management professions, education professions, transport professions and artisans where shortages are being experienced. (Connellan, 2007;
Department of Labour, 2007). It is interesting to note from this list that many of these skills’ are critical to the success of the supply chain, notably engineering, finance professions, law, IT/ICT, management, transport and artisans (Heyns & Luke, 2012). This list thus provides some indication of the magnitude of the supply chain skills’ shortage in the country. Globally the scarcest skills are the soft skills and hard skills, and perception is that most candidates lack a sufficient standard of soft skills (Lou, 2012). The scarcest global soft skills are regarded as languages, communications, team management and leadership and organisational skills and the scarcest hard skills are the financial and budgetary skills, IT, green skills, procurement and negotiation, research and development and healthcare skills (Heyns & Luke, 2012).

2.5 ENGINEERING SKILLS’ SHORTAGES

This study focuses on the skills’ shortages in the profession of the engineers. Engineering is a wide field that encompasses a number of professions across a number of industries. Moreover, the skills’ shortage exists not only in relation to engineering professionals, but also in relation to professional technicians and other people with engineering skills (Robbertse, 2012). Engineering skills are represented in most sectors of the economy and are used in many and diverse ways (Connor, Dench & Bates, 2000). It is common knowledge among the sector these days that there is a skills’ shortages in the engineering industry. According to Bloomfield (2015), more needs to be done to encourage the young generation to take up engineering and technology jobs if the sector is going to be able to fulfil its needs. The engineering industry in Britain is the one that drives productivity that benefits the economy, but the demand for people with engineering skills is huge and it gives concerns for the long term-future of the country (Engineering UK’s, 2016).

2.6 CAUSES OF ENGINEERING SKILLS’ SHORTAGES

The majority of the literature concerning engineering skills’ shortages acknowledges its existence and outlines the underlying contributors influencing shortages. It is important to identify the contributors influencing engineering skills’ shortages and establish solutions that can be implemented.

The demand for engineering skills’ in the fast growing industries around the world continues to be strong (Connor, Dench & Bates, 2000). Shortages of relevant people with experience and skill are causing difficulties for employers to fill vacancies (Luke & Heyns, 2012). Skills’ shortages are felt at all levels, especially among professional engineers, and also in skilled
trades (Connor et al., 2000). Different engineering sectors are subject to different pressures, which in turn have implications for skills’ (Connor et al., 2000).

The question is whether “there is an adequate supply of engineers around the world. From this question we need to ask ourselves what the causes of the engineering skills’ shortages are.

2.6.1 Poor career guidance in subject choices

According to Perkins (2013), young people are needed who are technically and academically competent, but who are also inspired by the possibilities of engineering. Inspiring young people and helping them to understand where different choices could take them in the future is crucial if engineering is to be able to draw on the full talent pool (Perkins, 2013). Subjects in the engineering courses are perceived as difficult and not so interesting, dull. Students lack awareness about the opportunities of studying the subjects (Perkins, 2013). There is also an effect of societal beliefs and learning environment on achievement and interest in science and mathematics (Mutodi, 2004). Mostly when parents and teachers intervene and encourage students that their intelligence can expand with experience and learning, they do better even in the subjects that they are struggling in and are more likely to say they want to continue to study in the future (Mutodi, 2004). According to Hill, Corbett and Rose (2010) the issue of self-assessment, or how we view our own abilities, is another area where cultural factors have been found to limit the interest in mathematics and mathematically challenging careers.

There is so much criticism around that engineering is not developing personal and transferrable skills’ sufficiently among graduates and this leads to losing too many students to other jobs and failing to use some of the engineering graduates appropriately and developing their skills’ (Grant & Dickson, 2006). According to the American Society for Engineering Education, engineering bachelor’s degrees declined in 2007 for the first time since the 1990s, ending seven years of growth. Engineering master’s degrees show an even sharper drop than bachelor’s degrees, having declined by 8.8 per-cent since 2005 (ASEE, 2010).

2.6.2 A retiring workforce

According to Brown and Gali-Debicella (2009) experienced professional workers have acquired knowledge and activities that made them proficient at their job, activities that were learned over time and which became part of their skill set. It is highly likely that 50 percent of
the entire workforce is due to retire by 2020, and the question arises how positions are going
to be filled if nobody has the skills’ (Brown & Gali-Debicella, 2009). Experienced workers who
are more mature can be part of mentoring and be part of the solution or they can make
matters worse by refusing to retire or share the knowledge they have with new graduates
(DeLong, 2014). The UK is currently experiencing an ageing population and the construction
sector is set to see more skills’ leave the industry than any other area of work. In addition the
baby boomer generation is slowly reaching the career finish line and employers are
understandably concerned that younger workers are not coming through to replace them.
(UKCES, 2014).

2.6.3 Negative perception of the industry

Construction in any country is a complex sector of the economy, which involves a broad range
of stakeholders and has wide-ranging linkages with other areas of activity such as
manufacturing and the use of materials, energy, finance, labour and equipment (Hillebrandt,
1985). The construction industry is not necessarily seen as the career of choice when
compared with other industries (Haupt & Harinarain, 2016). Despite the significant
contributions to the economy of a country, the construction industry is seen as an industry
with low quality, poor health and safety systems, chaotic working practices, a negative image
and an industry with high costs (Ball, 1988). Image in any career choice plays a vital role as
well as gender relations (Gale, 1994). According to Baldry (1997), career opportunities within
the construction industry are also considered to be poor. The construction industry is
associated with many negative images such as difficult working conditions, not clean, tedious,
hazardous and non-professional people (Reid, 1995). According to Schella (2010), parents and
teachers see a job in construction as a last resort when a job could not be found elsewhere.
There is a lack of well-defined career paths in the construction industry and this confuses many
people and students. Makhene & Twala (2009), agree that there is a lack of well-defined
career paths in construction. The potential salary and overall income package are important
to young people when choosing a career (Chileshe & Haupt, 2007). It is a general opinion that
jobs in construction pay less than jobs in other industries (Makhene & Twala, 2009). Young
people are of the opinion that it is not possible to make a career out of construction; they
generally do not know about the career opportunities that were available (Tucker et al., 1999).
There is a need for the industry to improve the image of the construction industry and recruit
new graduates (Griffith, 1988). The image of the construction industry needs to be revalued
to form a positive and attractable image to the society (Rameezdeen, 2007).
2.6.4 Poor pass rate in STEM subjects (Science, Technology, Engineering and Mathematics)

The role of science and technology in national development cannot be exaggerated. Any nation which fails to adequately consider science, technology, engineering and mathematics (STEM) education has planned to be left behind in all spheres of development (Ugo & Akpoghol, 2016). According to Banerjee (2016), socio-economic hardships put children in a deprived position. Disadvantaged pupils do not perform as well academically as their elite peers (Reardon, 2011; Steele, 2010). Strambler & Weinstein (2010), using a sample of 111 students from California, showed students’ higher perception of negative teacher feedback predicts more devaluing of academics and greater perceived teacher care at classroom level predicts less devaluing. International research indicates that 75 per cent of the fastest growing occupations require STEM skills’ and knowledge (Becker & Park, 2011). Most important is that the employment rate in STEM-related occupations is estimated to grow at twice the pace of other occupations (Craig et al., 2011). There are fewer than 40 per cent of the engineers employed each year in Australia (Beanland & Hadgraft, 2013).

2.6.5 Low remuneration for engineering professionals

According to a recent survey of 200 engineering firms, 74 per cent of employers listed “…a lack of qualified candidates” as their biggest hiring challenge over “specialized job requirements” and “non-competitive salaries” (Walpert, 2014). Lawless (2005) reports that salaries seem to be a distressing matter in the engineering sector. According to the findings salary inconsistency between engineers and other professionals contributes to the movement of most young professionals to other industries. Lawless refers to a recent study by the Higher Education Statistics Agency in the UK that found the reasons why most engineering graduates defect from other careers could be money and the image in the construction industry.

2.6.6 Lack of experiential training opportunities

Training systems are struggling to keep up with new demands in response to the construction techniques and the ever-changing building technologies in the building industry (Master Builders’ Association of Australia, 2006). It is very important for engineer graduates to acquire ongoing support and training in the workplace. Skills need to be developed, and training be made more attractive and accessible to ensure the future for the industry, otherwise the industry will face a rapid growth shortage of skilled workers (Hampson & Brandon, 2004).
2.6.7 Number of graduate drop-outs

Engineering is one of the scarce professions around the world (Writer, 2013). According to Prof Saurabh Sinha, executive dean of the Faculty of Engineering and the Built Environment, University of Johannesburg (UJ), a large number of engineering students tend to drop out of university within the first two years.

A study by the Human Sciences Research Council (2007) of about 34,000 students showed that of this number, only 14,000 students graduated, with some 20,000 dropping out of their courses, most of them being either in their first year or midway through their second year of study. Engineering students have been dropping out globally at similar rates for years. Given economic pressures—graduates face multi-disciplinary expectations from potential employers—there is an opportunity for engineering programs to be “re-engineered” (Writer, 2013).

2.6.8 Political instability

Economic growth and political stability are deeply interconnected. The uncertainty associated with an unstable political environment may reduce investment and the speed of economic development and poor economic performance may lead to government collapse and political unrest (Alberto, Ozler, Roubini & Swagel, 1996). Lower economic growth in most countries is being led by higher degrees of political instability (Jong-a-Pin, 2009). Socio-political instability reduces how private investors want to invest as the economic environment is uncertain (Alesina & Perotti, 1996). According to Aslam and Sajid (2008), any country to be uplifted depends on its industrial strength. Industries will be affected whenever there are unstable political conditions (Aslam & Sajid, 2008). When a country is facing unstable political conditions, organisations are forced to enforce changes in the process and the policies they use, especially the ones that are exporting and dealing with foreign customers (Sajid & Aslam, 2008).

2.6.9 Lack of government support for tertiary education

The rising cost of higher education is a global phenomenon not only in South Africa but countries such as Australia, Brazil, Germany, the Netherlands and the United Kingdom students have publicly protested against fee increases. Machika and Johnson (2014) indicated that entry into tertiary education for most of the students from poor backgrounds is a great...
opportunity to change their background and boost the economy as well, but it has been very difficult to achieve as the economic conditions impact on the ability to achieve academic success for most of the students. Without adequate financial resources available in institutions of higher learning, students’ experience of poverty may be only marginally alleviated, which merely extends and in effect produces systemic conditions of poverty (Machika & Johnson, 2014). In South Africa the affordability of higher education is a real challenge: state funding for higher education has been declining in real terms (1.1 per cent from 2000 to 2012), while the proportion of the gross domestic product going to higher education has remained around 0.7 per cent which is low by international standards (Langa, Wangenge-Ouma, Jungbult & Cloete, 2016). Free education is deemed necessary to get human capital investment to an efficient level (Langa et al., 2016).

2.6.10 Poor working conditions

The construction industry is regarded as one of the most dangerous industries, according to Hawkins and Wells (2013). More than 25 per cent to 40 per cent of work-related deaths occur on the construction sites, and there are a variety of health and safety hazards and risks to which everyone in the construction industry is exposed (CIDB, 2009). The variety of health and safety hazards to which construction workers are exposed include noise, irritants or sensitising materials, dusts, fumes and gases and other hazardous materials such as asbestos, which result in adverse health risks (Danson, 2012). Construction field employers are not respectful of the work-home boundary: mostly they expect their workers to take work home, work till late, travel often with little warning, lack of advancement and having to spend less time with family (Danson, 2012).

2.6.11 Growth of new industries with few ready skilled engineers

According to Darshanaben (2014), the education system in general and higher education in particular have not been proved efficient in making youths employable according to the needs of the job market. To enable an employment-ready workforce in the future, the youth need to be equipped with necessary skills’ and education (Darshanaben, 2014. A well-educated population, adequately equipped with knowledge and skills, is not only essential for supporting economic growth, but it is also a precondition for growth to be inclusive since it is the educated and skilled person who can stand to benefit most from employment opportunities which growth will provide (Darshanaben, 2014). Horn (2006) argued that teachers and the school system are not preparing learners adequately in terms of skills.
required for the world of work. He also argued that there are insufficient numbers of job opportunities in the market. An adequate number of suitably educated and skilled learners who enter the labour market would benefit the nation and society as a whole, as well as the enterprises that employ them (Skills Development Planning Unit, 2002). In the globalised era, competition has become more and more intensified amongst the industries, requiring improved and efficient quality of the services and products (World Bank, 2007). Competition in the industry forces more skilled workers to engage in innovation, but the entry requirements for youth seeking work have become higher and tougher because they do not have the skill required to be hired (World Bank, 2007).

2.7 EFFECTS OF ENGINEERING SKILLS’ SHORTAGES IN THE CONSTRUCTION INDUSTRY

2.7.1 Skill deficiency

There is a significant problem of filling vacancies owing to a shortage of people with the relevant skills coupled with experience (Klosters, 2014). Engineering employers are finding it more difficult to recruit people with technical and practical skills than any other skills (Connor, 2000). Skills’ deficiency is very evident in the existing engineering workforce.

2.7.2 Lack of innovative technology changes within the industry

New production services and processes are being led by change and innovation and are expected to continue with the development of new technologies which include nanotechnologies, nano-electronics and biotechnology (Dickens, Kelly & Williams, 2013). Engineers increasingly look for an ability to learn, but also an attitude of mind which predisposes people to be interested in and be proactive with learning new things (Wilson, 2012). Realising the economic potential of technological breakthroughs will rely on creating an infrastructure to move innovations from initial ideas into the market place. It includes further development of the links between industry, including small businesses, and research institutions including universities (Wilson, 2012).

2.7.3 Lack of quality relevance of the training received

Lacking experiential training opportunities for graduates comes as a big concern and contributes significant in the engineering and the construction industry (Lawless, 2005). Skills in the construction industry are not adequately developed (Hampson & Brandon, 2004). The
building technologies and construction techniques are forever changing and it makes it difficult and a struggle for anew training system to keep up with the new demands (Lawless, 2005). According to Toner (2005), revising training packages leads to more consistent delivery to the training system, and he addresses the key area of concerns as follows:

- Encourage a flexible course delivery and choice in training courses;
- Attract young people to trades training;
- Reverse the high rate of drop-out from training;
- Address the cost to small business employers when employing apprentices
- Reform industrial relations restrictions preventing more relevant and timely training.

2.7.4. Difficulties in recruiting right candidates for the job

Reports of a graduate engineer shortage are common yet competition for jobs remains fierce. The construction industry is finding it difficult to recruit high-calibre individuals (Harris, 2014). According to Oladapo (2014) it is stated that many companies do not provide the right training opportunities to harness the talent in the right direction. Given the current situation, engineers need to take a much more proactive approach with their careers. According to Zinyemba (2014), recruitment for staff for any industry is very challenging: skills’ scarcity, costs associated with recruitment itself and brain drain are identified as reasons (Zinyemba, 2014). Lack of human resources planning, geographical location of jobs and use of information technology in advertising are other challenges that employer organisations face when recruiting and selecting employees (Zinyemba, 2014).

2.7.5 Emigration

Emigration is the biggest worrying factor amongst others in the skills crisis. Countries around the world are suffering skills’ shortage. Most people are trying to improve their situations and living conditions, even if it means leaving their current environment to go seek for a better ones.

According to Bailey (2003), highly skilled individuals are contributing immensely to the society and the economy. Having to migrate forces separation from family and everything that is
familiar, but most individuals choose to migrate because of the factors that push and pull the country down (Bailey, 2003). There are many factors that influence people to migrate, it could be political uncertainty, environmental changes, cultural and economic changes: all these factors are types of push or pull factors (National Geographic Society, 2005).

2.7.6 A negative effect on the quality of higher education

Higher education is in high demand. It is also an important social and political issue in developed countries (Oppedisano, 2010). The overall education system of a country, from early childhood education until upper secondary, influences the selection, the knowledge and the attitudes of individuals who effectively enter higher education (Michaelowa, 2007). The industry’s view of the academic world is that it is not healthy, not what is needed; it is “stuffy” and could do with a “breath of fresh air” (Michaelowa, 2007).

2.7.7 Poor working environment and conditions

Most people are not keen on working on a construction site because of the site and hard working conditions. Many of the workers want white collar jobs (Bloomberg News, 2005). Construction activities are always happening outdoor with all the conditions of being exposed to hot weather conditions, changes in the nature of work, being mixed with different races and different working environments (Smallwood & Abrey, 2014). As buildings become higher and larger, the possibility of accidents occurring also increases. Accidents at the construction site do not only involve workers, but may also inflict injury or even cause death to the general public. Such accidents have tarnished the image of construction industry (Nelson, 2014).

2.7.8. Damage to the economy

Engineering skills’ shortages are inhibiting growth of the economy: economic opportunities cannot be productively viable owing to a lack of needed skills, including managerial, professional and technical skills’ (Sharp, 2011). Long-term growth potential of every country is being consistently undermined and there seems to be no growth drivers that could lead to a sustained recovery (Wehinger, 2011). There are other challenges that damage the economy such as political uncertainty which affect investment, inflation, a high employment rate, the trade deficit, a volatile exchange rate, crime but the biggest of them all is the skills’ crisis with which we faced (Sharp, 2011).
2.8 METHODS OF MINIMISING ENGINEERING SKILLS’ SHORTAGES

For success in today’s workforce one is required to have post-secondary development owing to changes and growth of technology happening every day in many business segments. The Bureau of Labour Statistics reports that eight of the 10 top growing occupations through 2014 do not require a bachelor’s degree (American Society for Training & Development, 2012). All young people should have access to the information that helps them to make informed choices to their future studies and careers (American Society for Training & Development, 2012). The first hurdle that must be surmounted in order to combat the skills’ shortages plaguing STEM industries is the lack of education among children and their parents of the opportunities offered by a career in STEM (Pickering, 2016). In order for the country to address the STEM problem, there need to be a partnership between the government, industry, businesses, professional engineering institutions and other third sector organisations (Perkins, 2013). The STEM community are already working hard to introduce new initiatives aimed at improving children’s engagement with science and engineering, but the number of young people graduating with STEM degrees is still far lower than it is needed to be (Perkins, 2013).

By hiring young engineers fresh out of university or apprenticeships, companies can benefit from having new minds to train in the way they prefer, as well as the imagination and ingenuity that often comes with being young and wanting to prove oneself. It can be achieved at a fraction of the cost of hiring an experienced engineer, especially with the current level of competition for talent driving up wages, and also provides the added benefit of feeling good about fostering a new generation of talent and forestalling the worsening of the skills’ shortage currently plaguing the industry (Pickering, 2016).

In research article by Pickering (2016), it highlighted the association between positive parental attitudes towards science, with discussion of experiences at school and engagement in enrichment activities particularly noted. Families are the most common source of careers advice for pupils, therefore, the importance of informing parents, including through enrichment activities and the development of science capital, cannot be underestimated (Engineering UK, 2015). There should be a link between economic development, education, and workforce development closely working together to meet the needs of employees’ programs (American Society for Training and Development, 2012).
2.9 LESSON LEARNT

The literature reviewed in this chapter showed that the major causes of the engineering skills’ shortages include the following: Poor career guidance in subject choice, retiring workforce, negative perception of the industry, low pass rate in STEM subjects, low remuneration trends for engineering professionals, lack of experiential training opportunities, and the number of graduate drop-outs. Additional factors that influence the engineering skills’ shortages in the construction industry were also identified in the literature and they include the following: skills’ deficiency, technology changes within the industry, quality and relevance of the training received, emigration, difficulties in recruiting, and poor working environments and conditions.

The study further identified the following as measures that can be used to minimise the engineering skills’ shortages in the construction industry: introducing of training programs, industry professionals being able to share their knowledge, participating in science, technology engineering and mathematics subjects, investing in education, companies providing additional training and development to staff, companies focusing on enhancing existing skills’ in their business, and using secondments, assignees or retirees for mentoring programs.

2.10 CONCLUSION

From the review of literature in this section, it was found that skills’ shortages exist not only in the engineering profession but in different occupations as well. It has a negative impact on the growth of the construction industry and the economy as a whole. There is currently an imbalance in the construction industry; the lack of qualified workers is hampering any continued growth. The diminishing workforce is a very real worry for employers and failure to bring through new entrants could prove detrimental to the long-term prospects of the industry.
3.1 INTRODUCTION

This chapter reviews the literature relating to two international countries, namely Australia and Canada. Firstly, this chapter focuses on the overall review of each country, and thereafter a review of the construction industry in each country is given, followed by an overview of the problems and challenges they face regarding the engineering skills’ shortages in the construction industry. Lastly this chapter examines lessons that can be learnt from both these countries regarding factors affecting the engineering skills’ shortages.

3.1.1 AUSTRALIA

3.1.2 BACKGROUND

Australia is ranked as the sixth largest country in the world with a population of just over 20 million people (World Population Review, 2017). Australia is the driest and flattest inhabited continent and has the oldest and least fertile soils. The largest part of Australia is desert or semi-arid and the western half of the continent is occupied by a desert plateau that rises into barren, rolling hills near the west coast. As of December 2014, Australia’s population comprised roughly 23.6 million people (Anderson, Gronn, Ingvarson, Jackson, Kleinhenz, McKenzie, Mulford & Thornton, 2007). The most populous states are New South Wales and Victoria, with their respective capitals, Sydney and Melbourne being the largest cities in Australia (Anderson et al, 2007).

Over the past five years the population has been increasing at an annual growth rate of 1.2 per cent, which was higher than that of most OECD countries. In terms of current trends, the population is projected to reach about 24 million by 2025 ((Anderson et al, 2007)). It is a highly urbanised society with two-thirds of the population living in cities of more than 100 000 people: almost 50 per cent of the population lives in the three largest cities (Sydney, Melbourne and Brisbane) (Anderson et al, 2007)).

Australia is a high-income country. Per capita income in 2005 was around US$32,000, which is one of the highest levels among OECD countries (OECD, 2006; (Anderson et al, 2007)). Like any other country, Australia has also been experiencing features of inflation and
unemployment (OECD, 2006; Anderson et al, 2007)). The GDP growth was forecast to be 3¼ per cent in 2012-13 and 3 per cent in 2013-14, with the economy expected to outperform every major advanced economy over this period (Commonwealth of Australia 2013). A rebalancing of economic growth towards non-resources sectors is needed to fill the gap. (Economic statement, 2013)

3.1.3 THE AUSTRALIAN CONSTRUCTION INDUSTRY

The construction industry is the fourth largest contributor to the gross domestic product (GDP) in the Australian economy and plays a major role in determining economic growth (Commonwealth of Australia, 2013). The industry had previously experienced seven consecutive years of growth as a proportion of GDP since the introduction of the goods and service tax (GST) in 2000-01 (Commonwealth of Australia, 2013). The construction industry makes a significant contribution to the annual growth of the Australian economy (Commonwealth of Australia, 2013). In 2011-12, the industry’s gross value-added (GVA) was $99.5 billion or 6.9 per cent of the Australian economy. In the same year, 1.043 million people were employed by the industry, accounting for nearly 10 per cent of all people employed in Australia (Economic statement, 2013). Construction and property have a hugely significant impact on productivity and efficiency of other industries. They also play a vital role in the Australian economy (Hampson & Brandon, 2012).

3.1.4 ENGINEERING SKILLS’ SHORTAGES IN AUSTRALIA

Construction industry in Australia is ranked as the third largest area of employment

The construction industry is the third largest area of employment in Australia, according to the Australian Bureau of Statistics. According to Pillai (2015), the demand for skilled labour in the residential and commercial sector has dipped to its worst level.

Engineers and engineering have been essential to the lifestyle and prosperity in Australia (Perkins, 2013). Engineering skills’ shortages result in poor quality, delaying construction projects and reducing investment and productivity growth in Australia (Mavromaras & Sloane, 2011). The effects of engineering skills’ shortages effects are felt diversely in sectors such as manufacturing, construction and infrastructure development (Mavromaras & Sloane, 2011). Infrastructure projects are impacting the private and public sector negatively (Perkins, 2013).
Engineering skills’ shortages have an impact on training and workforce development (Perkins, 2013).

3.1.5 CAUSES OF ENGINEERING SKILLS’ SHORTAGES IN AUSTRALIA

There is a shortage of experienced engineers and an inadequate supply of graduates in Australia. Another problem Australians are faced with is not having enough number of high school students and having to choose the necessary subjects to pursue engineering studies (ANET, 2012). Emigration is see as an option for most of the employers because of the shortage of engineering skills in the construction industry (ANET, 2012). The shortage of engineering skills in the construction industry in Australia will have the potential to have serious effects on the welfare of its citizens and the risks of bearing the cost of project being delivered late and being over the budget (UKCES, 2014).

According to Dawes and Rasmussen (2007), the number of students taking mathematics and science, the subjects for an engineering career, has dropped in recent years. The proportion of year 12 students studying appropriate enabling subjects in mathematics and science has continued to decline at the same time that skills’ shortages in engineering have emerged (Barrington & Brown, 2007). It is very difficult to believe that there is still no understanding to what engineers do by the general public. There has been very limited appreciation of the connection between mathematics, science and the real world, training for many maths and science teachers has been largely theoretical as well (Post & Cramer, 1989). It is critically important that there is investment in engineering training (Duderstadt, 2008).

According to Haupt et al. (2010), not having enough younger new entrants into the construction industry only increases the proportion of having older people in the industry, and it forces new entrants to lose interest as well in a career in the construction industry, especially since they do not have their peers to compete with and younger generations are more concerned with wages rather than job security and work that does not involve travelling a lot which are more of a concern to an older generation or older people (Liska, 2000).

3.1.6 EFFECTS INFLUENCING ENGINEERING SKILLS’ SHORTAGES IN THE CONSTRUCTION INDUSTRY

Engineering skills’ shortages impacts the productivity growth and reduces the investment of the country as projects well (Fitzhardinge, 2012). A report released by the Business Council of
Australian (2012) points to the $921 billion pipeline of investment in resources, energy and economic infrastructure, warning that Australia risks not being able to efficiently deliver projects because it is becoming a high cost and therefore high-risk place to invest (Business Council of Australia, 2012). Not having qualified candidates who have not acquired the necessary skills for the job being hired, can lead to mid-project changes which put pressure on timelines and costs. Engineering skills’ shortage negatively impacts the ability to develop scope documents going to tender.

3.1.6.1 Difficulties in recruiting

According to Healy (2011) hiring standards may be adjusted according to the state of the labour market: when demand is buoyant, employers may be forced to take on workers who lack experience. In contrast, when demand is depressed and labour is abundant, employers may raise their expectations and look for qualities beyond those required in terms of the technical capacity to perform the job (Richardson, 2007). According to Christie (2016), technology is changing almost every industry known to man and construction is no different: with all this new technology changing the industry, there is a lack of talent out there with construction experience. The construction industry’s reputation as being old-fashioned and set in its ways also makes it difficult to find the right calibre of candidate (Christie, 2016).

3.1.6.2 Poor quality and relevance of the training received

Retirement of skilled managers, professionals and artisans coupled with a deficient education and training system means a dwindling pool of human resources (Greenblat, 2008). Developing skills not only offers opportunities for work but also makes one creative and enhances people’s capabilities to work and be proud of what they do as well. Estimates for European countries show that a 1 per cent increase in training days leads to a 3 per cent increase in productivity, and that the share of overall productivity growth attributable to training is around 16 per cent (CEDEFOP, 2007).

3.1.6.3 Poor image of the construction industry

Construction industry has long been suffering from a poor image globally around the world (Rameezdeen, 2007; Chan & Connolly, 2012; Pearce, 2003; ILO, 2001; Makhene & Twala, 2009; Clarke & Boyd, 2011). According to Uttings (2010), a poor public image of the
construction industry as a career and the ambiguity of functions in construction, coupled with the perception that a career in construction means working 50 per cent more for 50 per cent less, forever being shipped from one site to another, is seen as a major factor. The industry is more associated with low quality work and poor health and safety matters as well (Rameezdeen, 2007). The poor image of the construction industry makes it less attractive for new entrants to even think about taking it as a career (Chan & Connolly, 2012; Clarke & Boyd, 2011). According to Chan and Connolly (2012), it becomes very difficult to retain and recruit a skilled workforce because of the poor image of the construction industry itself.

3.1.7 MEASURES OF MINIMISING ENGINEERING SKILLS’ SHORTAGES

Apprenticeships promote the importance of trade learning through industrial experience as the primary form of education within the construction industry (Harris & Simons, 2005). The government hopes to encourage 3 million new apprenticeships in all industries between 2015 and 2020 through a £12 billion investment (Harrison & Simons, 2005). The short-term skills’ gaps will have to be filled by migration, and keeping older workers working longer as investing in apprentices will not be felt immediately as it takes time to train the numbers needed. (CIOB, 2015).

Construction needs to advertise itself better, through social media. An American study suggests technology could attract the attention of young people (FWCI, 2013). It is a necessity for Australia to continue re-examining training and skills’ development packages to meet current industry demand (Toner, 2015). Collaboration between universities, industry and accrediting bodies offers great opportunities to make training more efficient. Currently the most comparable arrangement is students studying and working part-time. Universities will have need to have the facilities to train students and construction sites provide the experience, and this will make training far more relevant to what students are currently working on. Anet (2011) further added how important it is for the industry to increase internships and have mentor relationships with the universities.

3.1.8 CONCLUSION

The chapter highlighted literature relating to Australia by different scholars and commentators who have mentioned that the shortage of engineering skills has been negatively affecting the Australian economy prosperity.
3.2 CANADA

ENGINEERING SKILLS’ SHORTAGES IN CANADA

3.2.1 BACKGROUND

In this chapter, literature is reviewed with reference to Canada: its past studies and historical background, factors that cause engineering skills’ shortage in the construction industry and the intervention of the government of Canada to reduce the skills’ shortage.

Canada is the world’s second largest country. The nation is divided into smaller governing units known as provinces and territories and it has ten provinces and two national territories (World Factbook, 2014). The provinces are divided into the Atlantic provinces (Newfoundland and Labrador, New Brunswick, Prince Edward Island, and Nova Scotia), Quebec, Ontario, British Columbia, and the prairie provinces (Alberta, Manitoba, and Saskatchewan), and the territories of Yukon, Nunavut and the northwest territory (World Factbook, 2014). Canada's standard of living, as measured by GDP per capita, was $46,200, lower than that of the United States ($57,300) but higher than that of Mexico ($18,900) (World Factbook, 2014).

3.2.2 CONSTRUCTION INDUSTRY IN CANADA

Canada is widely recognized as one of the world’s largest markets for commercial, residential and infrastructure development (The Canadian Business Journal, 2013).

Infrastructure and construction have undergone tremendous growth over the past decade in Canada (The Canadian Business Journal, 2013). Lack of skilled and experienced construction workers, are major challenges: the construction industry will need to find some 322,000 new workers by 2024, just to keep pace with demand and to replace retirees in the intervening period (Atkinson, 2013). Construction in Canada is a strong indicator of the country's economic strength. It is a $171 billion industry that employs 1.24 million, and consumes 40 per cent of the country’s energy and 50 per cent of its primary resources. To remain vital, the construction industry is demanding better, safer, energy-efficient and more affordable construction materials and technology (The Canadian Business Journal, 2013).
3.2.3 ENGINEERING SKILLS’ SHORTAGES IN CANADA

Canada has an aging population, mainly because of the increased life expectancy and the fact that the baby boomer generation (born between 1946 and 1965) is reaching retirement age (Kormonicki, 2012). According to the statistics of Canada, the working age (aged 15 to 64) is expected to drop in 2031 (Ottawa, 2010). According to Kormonicki (2012) in his 41st report to parliament addressing current and future skills challenges “...labour shortages occur in instances when the number of new job openings, available as a result of retirement or an increased demand for people with the skills to fill the positions, is higher than the number of new job seekers in Canada, either recent graduates or people with foreign credentials in that field”. The aging of the population will have many consequences, such as slower labour force growth, and it will also create an increased demand in certain sectors (Mercenier, Merette & Fougere, 2005). Canadian productivity is impacted by skills’ shortages and it becomes an economic issue for the country (The Canadian Business Journal, 2009). The foundation for learning specialised skills requires an understanding of basic math and science (Morgan, 2014). According to Klosters (2014), broadening and improving the quality of early childhood is essential for building basic skills.

3.2.4 CHALLENGES OF THE ENGINEERING SKILLS’ SHORTAGES IN CANADA

Ontario is losing out on as much as $24.3 billion in economic activity and $3.7 billion in provincial tax revenues annually because employers cannot find people with the skills’ they need to innovate and grow in today’s economy (Stuckey & Munro, 2013). Ontario’s economy is experiencing major performance gaps due to misalignment between employers’ skills’ needs and the educational and skills’ attainment of key segments of the labour force (Stuckey & Munro, 2013). Ontarians have high rates of post-secondary education: a significant part of this education is underutilised, either because individuals are highly trained in areas for which there is little labour market demand or because some employers are unfamiliar with or unsure about how to engage the full range of their employees ‘skills’ (Stuckey & Munro, 2013).

3.2.5 MEASURES TO MINIMISE ENGINEERING SKILLS’ SHORTAGES

Ensuring the right number and type of young people selecting engineering as a preferred career choice by encouraging high school graduates to enter the engineering programme when making their career choices and selling engineering as a rewarding career choice also demonstrates its importance to society and challenges young people with the opportunity to
make a difference in the world (Andres, 2010). According to Klostes (2014), governments should support student participation in education, at least through upper-secondary schooling, and provide financial incentives to support employer-provided training, particularly for occupations in shortage or for workers that otherwise would not benefit from training. High quality career guidance helps inform educational and career choices that are more in line with available and foreseen labour market opportunities (Klosters, 2014). Employers can increase their training and development investments and provide more experiential learning opportunities, such as apprenticeships, co-op placements, and paid internships. Educators can better align programs to the needs of the economy (The Conference Board of Canada, 2013).

3.3 COMPARISON BETWEEN AUSTRALIA AND CANADA

From the literature it is evident that construction industry represents a large share in the economy of both Australia and Canada. Both the countries are having difficulties concerning the engineering skills’ shortages. When comparing the two there is no exception with regard to the engineering skills’ shortages. The construction industry has been gaining globally, but there is still shortages of professional skills. Major causes of engineering skills’ shortages in Australian construction industry are not having enough exposure for engineering courses, students not taking engineering subjects, and public lacking understanding of the engineering profession. Challenges causing engineering skills’ shortages have resulted in delivering and conceiving poor quality to the projects of both the countries.

3.4 CONCLUSION

From the literature reviewed it is apparent that engineering and related occupations such as engineering technologist and technicians are ranked as fields in which workers are most difficult to recruit. Most of the graduates lack clarity with regard to the requirements of the industry and students are not pursuing further courses in science and mathematics. There is also a lack of developing skills’ through educational programs and on the job training.
CHAPTER 4

ENGINEERING SKILLS’ SHORTAGES IN NIGERIA

4.1.1 BACKGROUND OF NIGERIA

In this chapter, literature is reviewed with reference to Nigeria past studies.

British influence and control over what would become Nigeria and Africa’s most populous country grew through the 19th century (The World Fact book, 2010). A series of constitutions after World War II granted Nigeria greater autonomy; independence came in 1960, following nearly 16 years of military rule, a new constitution was adopted in 1999, and a peaceful transition to civilian government was completed (The World Fact book, 2010). The government continues to face the daunting task of reforming a petroleum-based economy, the revenues of which have been squandered through corruption and mismanagement, and institutionalising democracy. In addition, Nigeria continues to experience longstanding ethnic and religious tensions. Although both the 2003 and 2007 presidential elections were marred by significant irregularities and violence, Nigeria is currently experiencing its longest period of civilian rule since independence. The general elections of April 2007 marked the first civilian-to-civilian transfer of power in the country's history and the elections of 2011 were generally regarded as credible.

4.1.2 OVERVIEW OF NIGERIAN ECONOMY

The Government of Nigeria has sustained far reaching economic reforms at the federal level particularly in public finance management, and the financial sector since 2003 (World Bank, 2009). The changes made economically and well advised policies have contributed immensely to the consolidation of macroeconomic stability and improving the overall economic indicators. Nigeria is the largest country in Africa with a population of 158 million people and accounts for 47 per cent of West Africa’s population. It is also the biggest oil exporter in Africa, with the largest natural gas reserves in the continent (The World Fact-book, 2010). With these large reserves of human and natural resources, the country is poised to build a prosperous economy, significantly reduce poverty, and provide health, education and infrastructure services to meet its population needs (Nigeria Factsheet, 2015). The economy of Nigeria had a strong growth between 2003 and 2010, averaging 7.6 per cent. Nigeria was among the first countries to adopt and implement the Extractive Industries Transparency Initiative (EITI) to
improve governance and the oil sector (The World Fact-book, 2010). Employment remains the major issue with an estimated 50 million underemployed youth. The government has expressed its determination to make job creation central to its economic strategy and has specifically targeted the information communication technology (ICT), entertainment, meat, leather, and tourism and construction industries (Nigerian Factsheet, 2015).

4.1.3 THE NIGERIAN CONSTRUCTION INDUSTRY

The construction industry plays an essential role in the socio-economic development of a country (Khan, 2008). The activities of the industry have considerable significance to the achievement of national socio-economic development goals of providing infrastructure, sanctuary and employment (Osei, 2013). The domestic construction sector happens to be one of the fastest growing sectors, with an impressive average growth of 7-8 per cent per annum (Osei, 2013). Field and Ofori (1988) stated that construction makes a noticeable contribution to the economic output of a country; it generates employment and incomes for the people and therefore the effects of changes in the construction industry on the economy occur at all levels and in virtually all aspects of life. The construction industry is contributing to the process development, it occupies a focal position in a nation’s economy (Oseghale, Abiola-Falemu, Oseghale, 2015). The construction industry contributes about 50 per cent of Nigerian government expenditure (Kaizer, 1987). With reference to available country-wide statistics, the impact of the construction sector as a whole is much greater, sectors such as mining, manufacturing, water and electricity included. (Osei, 2013). Studies show that the construction industries of developing countries, including that in Nigeria, faces many problems, and the reasons for these problems are caused by the economic weaknesses which these countries face: there are inadequate resources to devote to efforts to improve the industry, the industry also fails to receive stimuli by way of job opportunities; and the market forces which support innovation are not present (Ofori, 1993). Every person employed within the construction process makes a direct contribution, not only to the community in general but also to the nation at large (Ward, 1979). In the world labour market, there said to be over 100 million construction workers, constituting 6 to 7 per cent of the world labour force (Oseghale et al., 2015). Inherent underdevelopment of the construction industries in these countries means that they are unable to deal with their weaknesses, to make a strong case for help, or to contribute to the efforts which the government make to develop the industries (Ofori, 1993). Owing to these problems, the performance of the construction industries on projects in developing countries, including Nigeria, is poor in most respects including cost,
quality and productivity (Ofori, 2002). The Nigerian construction industry has similar contractual arrangements as the industry in Britain which has been found to be more unsuitable for developing industries (Oseghale et al., 2015).

4.1.4 ENGINEERING SKILLS’ SHORTAGES IN NIGERIA

The findings of the Chartered Institute of Building survey (CIOB) survey, 2008 indicate that shortages of skills’ continues to be a challenge for the construction industry and the issue is likely to worsen as the demand for construction increases. The engineering skills’ is one of the major resources for construction industry and the provision of the resources must be given adequate attention. According to Haas, Rodriguez, Glover and Goodrum (2001), the skills crisis in the construction industry is not peculiar to Nigeria: the records show that the USA is facing a long-term labour shortage. A similar situation in Germany concerning skills’ shortage is not different in Sri Lanka (Jayawardane & Gunawardena, 1998). The Nigerian construction industry employers are struggling to fill vacancies with professionals (Arowojolu- Alogwe, 2013).

4.1.5 CAUSES OF ENGINEERING SKILLS’ SHORTAGES IN NIGERIA

4.1.5.1 Poor education system

The foundation of a knowledgeable economy and society in any country is education and higher education (World Bank, 1999). There is a difference between having basic and higher education: having basic education increases the capacity to be able to learn, read and interpret information but, on the other hand, having higher education enables one to keep up with technological changes and increase the technical training needed to build a labour force. (Aniekwu & Ozochi, 2010). Educational institutions are under constant pressure to make workforce development more sustainable through innovative methods currently embraced by major organisations (Kalliath, 2002). The major and most important contributor to the growth of the economy is the type of tertiary education provided. The living standard of every individual and their happiness, not forgetting health and security, is determined by the education that one receives (Carnoy, 2014). The education standards in Nigeria have been declining and the drop-out rates in schools has been increasing. In addition, technical education has been considerably neglected as well (Aniekwu & Ozochi, 2010). It is said that an estimated 2.4 per cent of Nigerian’s GNP is spent on education (Osime, 2007). According to Carnoy (2014), the quality of education is regarded as a major issue: all schools assess
students based on examinations, projects, behavior in class, and effort. The manner in which the educational system of Nigeria is funded and administered is a serious problem for Nigeria (Aniekwu & Ozochi, 2010).

4.1.5.2 Lack of training opportunities

Perceptions differ of technical skills’ gained through construction industry programs because they depend on the construction industry’s expectations of graduates who join the construction industry in Ghana and Nigeria (Acheampong, 2013). Educational institutions are under constant pressure to make workforce development more sustainable through innovative methods currently embraced by major organisations (Kalliath, 2002). Improving education quality and raising skills levels and standards for training may not only lead to higher wages and higher returns but may impact individuals, employers, and the nation as a whole (Acheampong, 2013). The opportunities for graduates to obtain practical training in Nigeria are extremely inadequate and subsequently it is very difficult for Nigerians graduates to be accepted for postgraduate work around the world (Oseni, 1987).

4.1.5.3 Emigration

Nigeria is significantly affected by emigration in Africa. Between 1986 and 1990 Nigeria lost 10,694 professionals from tertiary institutions alone while total estimates, including those who left public, industrial and private organisations, are over 30,000 (Anekwe, 2003). Most of the countries that are affected by skilled labour migration are being seen as the losers while the receiving countries are been seen as the winners and this uplifts their economy as well (Suleyman, 2008). The receiving country that has not borne the costs of training and education is receiving developmental assistance and the sending countries that invested more in human resources are becoming poor nations (Avveduto & Brandi 2007). Migration tends to draw away the well-equipped and qualified people that will help their countries to better and improved living conditions (Gedamu, 2002). According to Gedamu (2002), the emigration of skilled workforce from Africa amounts to the depletion of the natural supply of intellectual talent and replacing this skilled workforce has cost her as much as $4 billion per annum.
4.1.6. THE EFFECT OF ENGINEERING SKILLS’ SHORTAGES ON THE NIGERIAN CONSTRUCTION INDUSTRY

The current dynamic technological world is in need of radical restructuring with the responsibility of imparting skills’ and knowledge to trainees (Femi, 2014). Nigeria has lost more than 1,000,000 immigrants to the United States alone and Nigerians and Africans are the most educated ethnic group in the group in the United States (Arowojolu-Alogwe, 2013). Eneh (2010) revealed that there is a decrease in technical apprenticeship practice and artisanal product and services: artisans are ageing and younger ones are not taking over from them, generating the fear and concern that by the next two decades artisans may be completely extinct. Technical skills promote their economic survival, thereby playing a vital role in development of the society. Uwaifo (2009) posited that technical skills’ enhance the relevance of individuals in society.

4.1.7. NIGERIAN INTERVENTION TO ENGINEERING SKILLS’ SHORTAGES IN THE CONSTRUCTION INDUSTRY

The construction industry occupies a sensitive position, as it plays a prominent role in the economy of any nation (Achenu et al, 2000). Femi (2014) observed that despite the importance of construction technicians to the industry, a large number of them are still untrained, even though the construction industry all over the world has been implementing skills acquisition programs to meet with the demand of change in technology. Adekoya (1999) claimed that for the Nigerian youth to be empowered economically they should be given an opportunity for the necessary skills acquisition and for this to be done it should be effectively implemented.

The majority of the industry’s workforce in Nigeria is unable to access training and the existing training institutions are being faced with increasing deficits because of the declining enrolments. The restructuring of training must address the following (Aniekwu & Ozochi, 2010):

- Recognise the need for rapid skills’ formation to achieve the quantity and quality required to meet the nations development programme;
- Create synergy with the changing realities of the industry;
- Promote access to training and career progression by the workforce, and emerging enterprise;
• Create an equitable and sustainable financing system for training and education, which recognizes the need for all participants to contribute;
• Align professional training needs to be more closely harmonized with development priorities and the delivery approaches; and
• Develop a focus on the specific requirements of public sector delivery management.

It is standard procedure in most schools globally that engineering students undergo an industrial training programme for a substantial percentage of their total training period: however Nigeria has no place for industrial training experiences for their students (Aniekwu & Ozochi, 2010).

4.1.8. CONCLUSION

The chapter highlighted a literature review relating to Nigeria. Various scholars and commentators have mentioned that the shortage of engineering skills has been negatively affecting the Nigerian economy and its construction industry.

ENGINEERING SKILLS’ SHORTAGES IN EGYPT

4.2.1 BACKGROUND AND OVERVIEW OF EGYPTIAN ECONOMY

In this section, literature is reviewed with reference to Egyptian past studies and historical background.

Egypt is the most populous country in the Arab world and the third most populous country in Africa, after Nigeria and Ethiopia. Most of the country is desert, so about 95 per cent of the population is concentrated in a narrow strip of fertile land along the Nile River, which represents only about 5 per cent of Egypt’s land area. Egypt’s rapid population growth – 46 per cent between 1994 and 2014 – stresses limited natural resources, jobs, housing, sanitation, education, and health care (World Bank, 2015).

Occupying the northeast corner of the African continent, Egypt is bisected by the highly fertile Nile valley, where most economic activity takes place (World Bank, 2015). The economic outlook for Egypt in 2016 was cautiously optimistic, partly based on the government’s ability to deliver on expectations, as well as effective implementation of the Sustainable Development Strategy and ongoing macroeconomic reforms (African Economic Outlook, 2016).
4.2.2 THE EGYPTIAN CONSTRUCTION INDUSTRY

The construction industry is promoting infrastructure required to develop socioeconomic development, and remains a major contributor to the growth of the economy (Hafez, Aziz, Morgan, Abdullah & Ahmed, 2014). The importance of the industry can be measured by how much the sector adds to the country’s economy through its contribution to the gross domestic product (GDP) and the position it occupies in any nation’s employment population (Sweis et al., 2009). The construction industry in Egypt is a multibillion dollar industry and it contributes approximately 15 per cent to 17 per cent of the GDP, with investment expected to reach US$21bn by 2017 (UKTI, 2013). With the high rate of population increase at 1.7 per cent per annum (World Bank 2012), construction work in Egypt is increasing rapidly to meet the needs of the growing population through the expansion of potable water systems, residential housing, hotels, sanitary drainage facilities and various infrastructure project (Mack, Choffnes, & Mack, 2009).

4.2.3 ENGINEERING SKILLS’ SHORTAGE IMPACT IN EGYPT

According to Aring (2012), skills’ shortages is a key factor to joblessness. In most cases after graduating graduates wait for 3 to more than five years for them to secure employment due to a lack of job opportunities (Handoussa, 2010).

Most of the candidates lack skills to enter the market and be recognised as suitable candidate for the job. Besides having the right skills to perform well in a team, lacking business communication skills is a problem (Stiwe & Jungert, 2010). Qualified employees who take the initiative in business and perform well in the market are needed by the employers to represent their companies well (Coplin, 2003).

The workplace is forever changing nowadays, and to meet students’ needs in the workplace and avoid passing on outdated knowledge and competencies, curricula should be reassessed periodically (Amin, 2008). According to Osman (2011), since employability skills are highly in demand in the job market, it is essential for the government to review its curricula to develop employability skills adequately. Communication, teamwork, problem solving, self-management, planning and organising, technology, life-long learning, and initiative and enterprise skills’ are the most needed for graduate employees (Clearly et al. 2007). Schools, universities and training institutions in Egypt are not producing graduates with skills that are needed in competitive labour markets (ILO, 2011). Graduates with employability skills are
more valuable in the working environment and more needed by employers than any other skills’ (Osman, 2011).

4.2.4 FACTORS RESPONSIBLE FOR ENGINEERING SKILLS’ SHORTAGES IN EGYPT

4.2.4.1 Poorly controlled education system

Universities and schools in Egypt are being controlled by a centralised system that does not allow ownership of controlling the curriculum and developing the budget for the programs and this makes it very difficult to expand and change the new system (OECD, 2009). Since there are no local decisions taken, it becomes difficult for Egypt to achieve the goals of the government and quality of education is deteriorating even further (World Bank, 2008).

4.2.4.2. Overcrowded Classrooms

Since the actual number of students entering higher education is about 60,000 per year, overcrowding of classrooms is a main factor in higher education (World Bank, 2008). An estimation of about 2,371,960 number of students were enrolled between the year 2005 and 2006 in public universities of Egypt (World, Bank, 2010). According to the report by the World Bank (2010), the would be an expected rise of 35 percent over the year 2006 and 2021 for enrolment in the higher education, and the youth population will rise from 55 per cent to 67 per cent over 2007 to 2020 for those who are working. There is a lack of technical and vocational education in the market, hence there are not enough graduates in the engineering field: this is largely because of the overcrowded classrooms (Osman, 2011).

4.2.4.3. Poor curriculum quality

According to Krafft (2012), the purpose of education is to provide the knowledge and skills’ young people need to access economic, political, and social opportunities and Egypt has made substantial progress in ensuring that nearly all youths enter school.

The poor quality of public education in Egypt is consistently cited by Egyptians across the board as a major impediment to both economic and political development (The Telegraph, 2011). Reformers agree Egypt needs an education system which encourages critical thinking, problem solving, teamwork and innovation, rather than rote memorisation (The Telegraph, 2011). One important dimension of any schooling system is how efficiently it uses its resources; if children are absent from classes, repeat grades, or drop out of school before completing their education, the schooling system is not efficiently providing youth with an
education (Krafft, 2012). One common deficiency in the Egyptian educational system is grade repetition, it takes a youth two years to master one year of material, and this is an indication of both poor school quality and a waste of educational resources (Krafft, 2012). Further skills are not being taught to students by university professors as they use outdated information to plan their curriculum (Kenawy, 2006). Engineer graduates need practical training. Curricula in Egypt are taught for years and mostly not updated, and the majority of the universities do not value research productivity or innovation (Kenaway, 2006).

4.2.4.4. Government to subsidise full tertiary education

The education expenditure of Egypt in 2007 was 6 per cent of the GDP, which is low by international standards, making it very challenging for the government of Egypt to subsidise the tertiary education compared to the increasing number of students enrolling in the universities (Ministry of Finance, 2011). Egypt is having difficulties in providing funding for tertiary education and this is the cause of poor education infrastructure and lack of improvement in the educational process (Osman, 2011).

4.3 LESSON LEARNT FROM NIGERIA AND EGYPT

From the literature review it is apparent that the skills’ shortages have been collapsing the economy and production of both Nigerians and Egyptians. It is certain that the construction industry plays a major role in the economy of these countries. Infrastructure development is in danger of collapsing because of not having enough professionals in the engineering sector. The poor education quality of Nigeria is mostly one of the causes of the engineering skills’ shortage and this forces the pupils of Nigeria to move to other countries for a better. Most of the time after graduating they look for employment in the countries they moved to when they were studying and do not return to their country of birth. This makes it very difficult for their own countries to be developed and grow. Egyptians are also struggling with their educational systems: the system is not efficient and this is not helping the youth of Egypt at all. Most of the candidates in these two countries are lacking the necessary skills to get into the market and perform well in their jobs. Lacking the right skills to solving problems in business is also a problem: employers are not only hiring based on the qualifications but also the skills that promote employability.
4.4 CONCLUSION

The chapter highlighted facets of a literature review relating to Egypt. Previous studies mentioned that their education system does not equip students with diverse skills, or assistance with funds to further their education. The poor quality of education received does not enable young people to be employable in industry and this is affecting the country in a negative way.
5.1 BACKGROUND OF SOUTH AFRICA

In this chapter literature is reviewed with the intention of conceptualising the problem statement and the objectives of the study. In particular, this literature review includes reference to past studies and the historical background regarding the shortage of engineering skills in the construction industry of South Africa.

South Africa is located at the southern tip of the continent of Africa, with a total area of 1,219,090 sq. km. The South African population consists of 80.2 per cent blacks, 8.45 per cent whites, 8.8 per cent coloured people and 2.5 per cent Asians. There are 12 official languages (IsiZulu, 22.7 per cent: isiXhosa, 16 per cent: Afrikaans, 13.5 per cent: English, 9.6 per cent: Sepedi, 9.6 per cent: Setswana, 8 per cent: Sesotho, 7.6 per cent: Xitsonga, 4.5 per cent: siSwati, 2.5 per cent: Tshivenda, 2.4 per cent: isiNdebele, 2.1 per cent: sign language, 0.5 per cent and other 1.6 per cent according to an 2011 estimate. The population numbers 53,675,563.00 (World Factbook, 2015).

5.2 OVERVIEW OF SOUTH AFRICAN ECONOMY

South Africa is a middle-income emerging market with an abundant supply of natural resources; well-developed financial, legal, communications, energy, and transport sectors; and a stock exchange that is Africa’s largest and among the top 20 in the world. Economic growth has decelerated in recent years, slowing to just 1.5 per cent in 2014 (World Factbook, 2015). South Africa is a member of three key regional economic communities: the Southern African Customs Union (SACU), the Southern African Development Community (SADC) and the Tripartite Free Trade Area. The objective is to harness regional integration at all these levels by focusing on market integration and infrastructure development so as to stimulate economic development and job creation, encourage trade and achieve economies of scale by the member countries (Chulu, Kumo & Minsat, 2016).

5.3 CONSTRUCTION INDUSTRY IN SOUTH AFRICA

The construction industry plays a vital role in the South Africa and is a significant contributor to economic growth in the country (Construction Industry Development Board [CIDB], 2012).
Although the industry’s current contribution to the gross domestic product has shrunk to approximately 3 per cent, compared to 7 per cent in the 1970’s, it remains an important economic sector (CIDB, 2004). In addition, the construction industry in South Africa accounts for 10 per cent of the world’s economy (CIDB, 2004). According to PricewaterhouseCoopers (PWC) (2013), the South African construction sector was depressed prior to 2010, with a decidedly negative sentiment in the market. The construction industry in South Africa is diverse since it involves the construction of civil infrastructure such as bridges, dams, roads and ports as well as the development of residential and commercial structures (PWC, 2013).

According to the Department of Public Works (2007), construction sector employs an estimation of around one million people. Construction industry has a critical role to play in developing the formal and informal sector of the South African economy. Skills’ shortage is one of the biggest challenge facing the South African construction industry.

5.4 ENGINEERING SKILLS’ SHORTAGES IN SOUTH AFRICA

In South Africa, one of the most serious structural constraints with regard to economic growth and unemployment is skills’ shortage (The Centre for Development and Enterprise (CDE) 2010). Lack of a skilled workforce is one of the constraints to the expansion of business operations in South Africa (Grant Thornton’s International Business Report, 2012). South Africa is short of 1000 engineers with five years of relevant experience (Styan, 2008). According to Lawless (2005) both private and public sectors are seeking experienced engineers. The supply side of the engineering profession is dependent on the number of students coming through the education system with the type of quality education that will enable them to make it through the tertiary institution (Lawless, 2005). The apartheid system is also a cause of the skills’ shortages in South Africa, as blacks were racialized, gendered and did not have access to skills’ development (Akoojee & McGrath, 2007). There is clearly a definite need for engineers (and professionals with engineering skills) of all sorts across a range of South African industries. This scarcity of skills, however, also presents unskilled workers with a definite opportunity to fill the skills’ shortage. StatsSA (2015) revealed that South Africa’s unemployment rate currently stands at 25 per cent, and one of main goals that South Africa has set itself in the National Development Plan is to cut the unemployment rate to 6 per cent by 2030 (The Presidency, 2012). Lewis (2002) even warned that without an adequate pool of skilled people, South Africa would not be able to overcome its most pressing problem, namely sustaining economic growth, and job creation.
5.5 CAUSES OF THE ENGINEERING SKILLS’ SHORTAGES IN SOUTH AFRICAN CONSTRUCTION

5.5.1 Poor education system

The strong legacy of apartheid and the consequent correlation between education and wealth have meant that, generally speaking, poorer learners in South Africa perform worse academically (Spaul, 2015). Bhorat (2001) also expressed the view that the unequal education system of the apartheid era is a significant factor, since it differentiated along racial and gender lines, thus adding to the poor quality of education. Levisohn (2008) added that blacks were deliberately subjected to a second-class education, labour laws were established to impede their advancement, business policies prohibited them from owning a firm, and certain laws kept them from occupying places and living in many of the metropolitan areas that were the centre of trade. The education of black people was inferior and of very poor quality (Spaul, 2015). The poor quality of education that learners receive helps drive an intergenerational cycle of poverty where children inherit the social standing of their parents or caregivers, irrespective of their own abilities or effort (Spaul, 2015).

5.5.2 Low pass rate in science, technology, engineering and mathematics (STEM)

Any nation which fails to adequately consider science, technology, engineering and mathematics (STEM) education has planned to be left behind in all spheres of development. Speedy and viable growth of a country can only be attained through scientific research and coherent application of STEM knowledge and skills (Okeke, 2008). Ikeobi (2010) mentioned that the contribution of STEM to social, industrial and economic life of the world has been felt in all phases of human life. The knowledge of STEM has enabled the provision of good water, food, healthcare delivery, various materials for construction in industries, roads, automobiles, and houses (Ugo & Akpogol, 2016). STEM-related subjects are used in solving problems resulting from human interaction with the environment such as water and pollution (Ugo & Akpogol, 2016). Okeke (2008) mentioned that there is an increasing concern about the poor retention and throughput rates of undergraduate’ students in South Africa. Despite the relevance of knowledge of STEM related subjects to the society, achievements of students in science subjects as measured by their scores in senior secondary school certificate examinations have been very poor. It is worrisome to note that STEM has not been embraced as expected (Ugo & Akpogol, 2016). Sustainable development suffers where such is experienced: it is a worry if a nation is lagging behind in this area as it concerns the teaching and learning of these subjects (Ugo & Akpogol, 2016). The poor quality of the education
system, especially in mathematics and science, has contributed further to the skills’ shortage with few students obtaining matric passes in those subjects required by fields such as engineering (Derek, 2013). Many of those who do enter university have not obtained the required knowledge in high school to cope with the standards set by universities (Carte Blanche 2012).

5.5.3 Overcrowded classrooms in higher education

The maximum recommended learner-educator ratio for South African primary schools is 40:1 and for secondary schools 35:1. However there are schools in South Africa that have far more learners in one classroom (Motshekga, 2012). When it comes to education, and specifically when it comes to class size, more is the exact opposite of better (KEZI 9 News, 2012). Unfortunately for South Africans, overcrowded classrooms are a challenge and will remain so for the future (Marais, 2016). Training programs that enable student teachers to deal with problems of teaching overcrowded classrooms must be addressed by the training institutions (Marais, 2016). If newly appointed teachers lack exposure to teaching overcrowded classrooms, it can be overwhelming to them to have larger class sizes (Opoku-Asare, Agbenatoe & DeGraft-Johnson, 2014). It is a challenge for teachers to produce a productive learning environment and effective teaching in overcrowded classrooms (Opoku-Asare et al., 2014).

5.5.4 Poor curriculum quality

According to Okello and Kagoire (1996), implementing curriculum activities involves changing peoples’ attitudes to accept and be involved in those activities implemented. The learners experience the quality of education by participating in classrooms (DoE, 2001). Government is providing less money for education thus in most cases the quality of curriculum is lacking (Sibulwa, 1996). According to Spaul (2015), quality education can be defined as the acquisition of the knowledge, skills’ and values that society deems valuable – usually articulated in the curriculum. It becomes very much possible for comparison of the level of education, knowledge and learning of pupils in South Africa with those in other countries (Spaul, 2015).

5.5.5 Poor tertiary education

There is a challenge in South African education to obtain a balance between students and having enough lectures and professionals to teach and train them (Cameron, 2008). Lack of a
sufficient number of adequate trained teachers is the cause for the low number of matriculants passing higher grade mathematics and science subjects. Teachers are not properly qualified (Mgibisi, 2007). School grades are no longer considered an authentic measure of preparedness for university study (Styan, 2008).

5.5.6 Number of graduate drop-outs

According to a study by Murray (2014), there is a large number of potential factors that may have a causative effect on the length of time that it takes students to graduate or drop-out from university-based studies. Some of these factors – such as a student’s age, gender, race and financial status—may be easier to measure than others, such as a student’s level of motivation for studying, the level of academic integration and the type of living conditions that exist at the university where they want to study (Murray, 2014). According to Richardson (2007), not enough graduates are produced from the tertiary institutions with qualifications that are relevant are able to keep up with the labour market demands.

According to Betty Enyonam Kumahor, regional director for Thought Works Pan-Africa, students at secondary school-level often do not know what types of careers will be open to them if they take maths and science. There is a popular perception among students that these subjects are more difficult than others. Lack of support as well from families and not having enough viable role models for students are also reasons for most of these students making wrong career choices and dropping out from the universities as well. There is a lack of qualified technical educators in most of the schools. There is a perception that a career in the engineering industry is male dominated which discourages most female learners from pursuing it at tertiary level and a career in the engineering industry is not seen as a family-friendly choice as it is characterised by long hours at work, especially in the construction industry.

5.5.7 Poor career guidance in subject choice

Reasons that give rise to the skills’ shortage could also be linked to globalisation because international organisations also recruit engineers in South Africa and offer them high salaries (Bary & Jordaan, 2009). The situation of poor career guidance in subject choices is problematic even if there are educational innovations such as bridging and extended degree programs to address the situation (Dyer, 2013). Income distribution inequality became even worse after the South Africa’s new dispensation in 1994: the real incomes of blacks fell whereas the incomes of whites increased during the period of 1995 to 2000 (Bond, 2005). Previously most
children had not been encouraged to study mathematics and science, resulting in fewer maths and science teachers in the country (Dyer, 2013). A solution is industry-funded secondments as well as job swaps where those within the profession would welcome higher-education funded infrastructure where academics and engineers from industry swap jobs for periods of one year, and where such academics have to spend this one year in industry every 10 years to refresh knowledge and learn how industry has changed within the ten-year period (Dyer, 2013). To create opportunities for sufficient experienced engineers to teach in higher education and make the necessary impact on a large enough scale there would need to be some financial encouragement, thus allowing smaller companies to hire contract engineers while their own engineers are seconded to higher education (Dyer, 2013). According to South African Government Information (2007), career guidance education has to play a positive role in the schooling system in order for leaners to attain information at an early age, and our country is lacking guidance teachers to give information to pupils at a younger age. Most schools do not have clued-up guidance teachers who give necessary information to the pupil regarding career guidance. The quality of teaching and learning in higher education is a huge concern globally (Biggs 1999; Ramsden 2003).

5.5.8 Immigration of experienced engineers and rising crime

Crush and McDonald (2003) confirm that many South African skilled professionals migrated to other parts of the world during the advent of the new political dispensation, as they feared the effects of affirmative action policies, violence, and other policies that have also worked against the country’s skills’ shortage. South African engineers are seen as suitable candidates for employment abroad in a variety of industries (Hamlyn, 2008). Emigration of skilled professionals is also a cause of the skills’ shortages (Alam & Hoque, 2010; Crush & McDonald, 2003; Fourier, 2006). These factors can be classified as push and pull factors (Kline, 2003). Generally push factors are present in leaving countries, and pull factors pertain to the receiving countries (Garbayo & Mabena, 2009). The table below Fourier (2006), depicts the push-and-pull factors:

Table 2: Push and Pull Factors of emigration in South Africa

<table>
<thead>
<tr>
<th>Internal/push factors</th>
<th>External/pull factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crime</td>
<td>Wage differentials</td>
</tr>
<tr>
<td>Fear of the Aids epidemic</td>
<td>Differences in quality of life</td>
</tr>
<tr>
<td>High unemployment rate</td>
<td>Educational opportunities for children</td>
</tr>
<tr>
<td>------------------------</td>
<td>----------------------------------------</td>
</tr>
<tr>
<td>Unequal levels of education</td>
<td>Intellectual freedom</td>
</tr>
<tr>
<td>Low eroding wages and salaries</td>
<td>Political stability</td>
</tr>
</tbody>
</table>


The shortage of engineers in South Africa hinders the ability of government to sustain the economic growth needed for development and eradicating poverty (Van Rooyen et al. 2010). Thakali (2008) estimated that there are 300 engineering emigrants from South Africa per year. The reasons for their leaving South Africa include discontentment with the application of policies to address past imbalances such as affirmative action, a lack of faith in the economy and the lure of better prospects in other countries (Thakali, 2008). Many people were affected by affirmative action because government was not showing interest in their skills or talents. South Africa was losing professionals through immigration even before the democratic dispensation of 1994 (Bailey, 2003). According to Crush (2002), globalisation has led to the mobility of people and the country is losing skills at a high rate because of better prospects in developed countries. The statistics indicate that about 118 000 skilled professionals have been lost through emigration since the early 90s (Stern & Szalontai 2006). According to the EIU, the continuing loss of skilled professional is posing a threat to the South African economy’s strong growth (EIU 2006). In an argument presented by Barker (2003), the education system is awarding more social science degrees. This implies that the country is losing much more skills that it is producing.

5.5.9 Quality and relevance of training received

The mostly majority of young people do not find jobs after graduating because of insufficient or inappropriate work experience received when they underwent some form of training (Breier & Erasmus, 2009). Students find it difficult to find work experience due to the poor quality of teaching in the classrooms and having no structured training workplace system for students (Goodsir et al. 2009; Breier & Erasmus, 2009). Government-funded training programs did exist in South Africa, but access was highly bureaucratic and many firms did not have the capacity to access them (CIDB and Department of Public Works, 2007). In addition, most programs are not developed because of the weak links between academia and industry (UNESCO, Engineering Report 2010; ICE/GDC, 2002e).
5.5.10 Political instability

Uncertainty associated with an unstable political environment may reduce investment and the speed of economic development, and poor economic performance may lead to government collapse and political unrest (Alberto, Ozler, Roubini & Swagel, 1996). Barro (1991) finds that measures of political unrest, such a number of assassinations and the occurrence of violent revolutions and military coups significantly affect the average growth level in cross-section regressions on a large sample of countries. In addition, Kormendi and McGuire (1985) and Barro (1989) found that a measure of the extent of political rights is positively correlated with growth.

5.5.11 Retirement of experienced engineers

Mid-career staff are being overworked because of shortages of junior engineers, and they also do not have time to train the junior staff even if they have juniors (SAACE, 2007). Most engineers lack qualities of managing and effectively ensuring that they use requisite standard of quality, cost and the time frame for infrastructure delivery (CIDB, Department of Public Works report Skills’ for Infrastructure Delivery in South Africa, 2007).

5.6 EFFECTS OF ENGINEERING SKILLS’ SHORTAGES ON THE SOUTH AFRICAN CONSTRUCTION INDUSTRY.

5.6.1 South Africa becoming a less attractive place to invest in

Engineering skills’ shortages contribute to high levels of unemployment (Leibbrandt, Woolard, McEwen, & Koep, 2010). Engineering skills’ shortages impact negatively on both the public and private sector (Leibbrandt et al, 2010). Lack of skills’ shortages, not only engineering skills is a major contributor of crime, violence and poverty in South Africa (CDE, 200; Ploch, 2011; Wallis, 2002, Weatherburn, 2001). Skills’ shortage affects work performance: the quality of work also deteriorates with no satisfaction, delaying companies in developing new products that increases costs (Wallis, 2002). Lack of engineering skill’s shortages left most of South African townships and squatter camps without basic services such as water, electricity and sanitation in our country (Babarinde, 2009; Landman, Bhorat, Van der Berg & Van Aardt, 2003).
5.6.2 Damage to the South African economy

Black people are living in poverty and informal settlement surrounds most major cities across the country (Ploch, 2011). Unavailability of a skilled workforce curbs business growth and also affects the country’s social and economic development because investors are rather unwilling to invest given the fragility of the country’s economy (Moser, 1999). The country’s economy growth and infrastructure development are being impacted by the engineering skills’ shortages, thus limiting the ability of the country to use its abundant natural resources and be competitive (Juma, 2006).

5.6.3 Poor quality delivery

Walker and Shen (2000) point out that in most cases project delivery are negatively affected by the skills’ gap that are labour-related. Mbeki (2014) declared that, despite the wide spectrum of factors affecting construction productivity, it is notable that workforce skills’ development and training featured is a commonly cited factor that affects timely project delivery. The capacity for South Africa to develop infrastructure services is very limited (Lawless, 2007). The infrastructure delivery is also hindered in terms of time, quality and cost because of the shortage of qualified professionals the country faces (Department of Public Works, 2007).

5.7 MEASURES TO MINIMISE CURRENT ENGINEERING SKILLS’ SHORTAGES IN THE SOUTH AFRICAN CONSTRUCTION INDUSTRY

For South Africa to address the skills’ shortages, the government has embarked on a number of initiatives (Gauteng Provincial Government, 2009). One of these initiatives is the formation of institutions such as the Sector Education and Training Authorities (SETA), which is mainly funded by skills development levies from employers that pay 1 per cent of their workers’ pay and the Joint Initiative on Priority Skills Acquisition (JIPSA). The aim of JIPSA is to concentrate on developing skills that are most immediately needed in the country, while the education and training authorities (SETAs) provide sector-specific training programs (Mateus, 2012). Whilst it is understood that government has established a number of initiatives to help address education and skills issues, many organisations have also focused on developing their people through learnership programs and bursaries in order to build capable and highly skilled labour which is required to capitalise on opportunities that are available for growth (Mateus, 2012). It is the role of South African organisations to establish contacts in the form of
partnerships with educational institutions to produce the type of skills required in the labour market. Partnerships are important because this is the only way that learners will be prepared for what awaits them in the industry (Nkosi, 2008).

One of the leading companies in the construction industry in South Africa has taken the initiative to address the shortage of skills’ through comprehensive collaboration with various institutions such as universities, colleges, and schools that promote the development of skills’ in mathematics (Hall & Sandelands, 2009). The company has also set aside bursaries to pay for students who are taking courses and subjects that are most needed, or where there is a scarcity of skilled labour force, including learnership programs.

It is very important that training providers and relevant institutions go into partnership to produce qualitative technical education, which is important to boost competitiveness in the world of business, and to prepare learners for what awaits them in the industry (Nkosi, 2008).

Several sources such as CDE (2007) and Maharaj (2004) have shown that we should not see immigrants as parasites, as South Africans have at times described them but as contributors to the economy of our country. South Africans should not see the importation or recruitment of skilled professionals from abroad or immigrants who reside in the country as a threat to them, but rather as something that will improve the education and training system that is currently failing them; improvement in managing the developing projects in improving the lives of many; business opportunities that will create employment and expanding opportunities for others (CDE, 2007). In most cases on an average immigrants work harder, have more energy and are better educated as well than the people in the host population (Meintjies, 1998). Coetsee and Keevy (2006) argue that if a well manageable system is established to manage migration and immigrants regarding their qualifications, it will be more beneficial to the country as tab will be kept on the statistics of the people that enter the country.

According to Hall and Sandelands (2009), one of South African organisations’ roles is to conduct a skills’ survey within their own companies to establish education levels and potential for development amongst their employees, as well as establishing skills’ development plans to help tackle areas where skills’ should be transformed.

Universities are academic institutions where research is conducted, teaching and learning is offered as well as support by networking, cooperation and collaboration with external
academic partners to create, develop and transmit new knowledge (Du Pré, 2009). Universities have the capacity to educate, empower people with skills’ and develop a society that is capable of tackling issues which face them. Tertiary institution are seen as centres for skills’ acquisition, and learning and development that support government’s duty to advance the socio-economic development of the nation through the enhancement of the skills’ of its citizens (Iwu & Xesha 2011).

Hall and Sandelands (2009) state that learnership programs are aimed at those on the job, as well as graduates who come into the industry. Graduates who complete their studies are immediately placed on learnership programs where a combination of theory with practice is in place, focusing directly on learning outcomes, which ensure that these graduates receive enough exposure to receive those skills which are required by companies (Mateus, 2012)

5.8 LESSONS LEARNT

From literature review it is clear that South Africa is experiencing a high level of engineering skills’ shortages. There are factors that contribute to the scarcity of engineering skills’ shortages and this impacts badly on the infrastructure development. Most of the qualified professional engineers are migrating to other countries because of the effect of violence, crimes and political instability in South Africa. The country’s social and economic growth is also affected by the engineering skills’ shortages and many investors are not willing to invest either. Having the senior older engineering professionals who are overworked and with no time to train the junior engineers is also a factor that contributes to the skills’ shortages. For the country to strive toward economic growth and global competiveness, the government needs to come with solutions to overcome the engineering skills’ shortages with which we are faced with.

5.9 CONCLUSION

This chapter gave an in-depth literature review of the shortages of skills in the South African construction industry. Findings revealed the challenges faced in South Africa in terms of engineering skills’ shortages in the construction industry. The next chapter will discuss the research methodology and the procedure followed during the study in order to achieve the goal of the study.
CHAPTER SIX

RESEARCH METHODOLOGY AND DESIGN

6.1 INTRODUCTION

The chapter focuses on quantifying the causes of the engineering skills’ shortages in the construction industry and identifying the effect the engineering skills’ shortages have on the South African construction industry. It also suggests the strategies to be used to reduce the engineering skills’ shortages in South Africa.

6.2 RATIONALE FOR THE STUDY

The rationale of the current study is to contribute to the body of knowledge on the factors responsible for the engineering skills’ shortages in the South African construction industry.

6.3 RESEARCH APPROACH AND DESIGN

Mutai (2000) defines research as a systematic search for pertinent information which leads to new knowledge. It encompasses investigations into relationships among different factors operating in a given situation. Research is the study of problems through the use of scientific methods and principles. It implies exhaustive study, investigation or experiments following some logical sequence (Goddard & Melville, 2001). Research, according to Welman and Kruger (2001), involves the application of various methods and techniques in order to create scientifically developed knowledge by using objective methods and procedures. It is the duty and function of the researcher to contribute to the understanding of the phenomenon and to communicate further that understanding to others.

Research method is the way in which ideas and evidence are organised and scattered. According to Babbie and Mouton (2001), research methodology or methods are sets of procedures that enable researchers to collect data that should be carefully planned, structured and executed in order to produce unquestionable and high quality research results. Pekeur (2002) states that research methodology aims at testing the nature of the scope dealing with the purpose and objectives of the study. Burns and Grove (1993) define quantitative research as a formal, objective, systematic process to describe and test relationships and examine causes and effects interactions among variables.
Quantitative research survey is simple self-reporting system by getting information from a sample of people and reporting on the questions posed by the researcher (Polit & Hungler, 1993). Hence, the current study adopted the quantitative research approach to determine the causes, effects and measures of minimising engineering skills' shortages in the South African construction industry. When conducting a study that makes use of quantitative research, the numerical measurement of specific aspects of phenomena is imperative and should be precise. The current study collected information through a well-structured questionnaire which was distributed to the respondents by the researcher.

6.4 RESEARCH AREA

The study was carried out in the Gauteng Province of, South Africa. The target group in the research area were professionals involved in the construction industry which included architects, quantity surveyors, electrical engineers, construction managers, construction project managers, project managers and other professionals in construction projects in Gauteng Province, South Africa.

6.5 TARGET POPULATION

The target population for this study is mainly people working in the construction industry in private and government institutions. The target population for the current study were architects, quantity surveyors, civil engineers, construction managers, construction project managers, project managers and other professionals who are involved in construction projects in Gauteng Province, South Africa. This was accomplished with the aid of structured questionnaires distributed to the respondents who are professionals in the field of construction in Gauteng, South Africa.

6.6 SAMPLE SIZE

Sampling is the process of taking any portion of a population or universe as a representative of that population or universe (De Vos, Strydom, Fouche & Delport, 2009). Burns and Burns (2008) define sample as a proportion drawn from the targeted population.

The sample size for this research included architects, quantity surveyors, structural engineers, electrical engineers, civil engineers, mechanical engineers, project managers, construction managers, construction project managers and other professionals involved in the construction
industry. The researcher decided to target the professionals in the construction industry to obtain their perceptions regarding the problem under investigation.

The researcher decided on the size as she considered the size to be manageable, taking into consideration that most of the questionnaires were distributed via email. As part of the sample, professionals from the consultants and contractors were selected randomly in the Gauteng area. From a 200 population sample, only 153 samples were returned back.

6.7 SAMPLING

Participants were selected randomly using a random sampling technique. The random sampling technique was preferred and adopted in the current study because it is very convenient when working with small populations that have already been identified and listed rather than the stratified sampling, cluster sampling and sampling using multiple probability techniques. Random sampling was adopted because it gave all the participants an equal chance to be selected and all participants were selected with the same criterion, namely being construction professional practicing in Gauteng, South Africa.

6.8 DATA COLLECTION

A list of potential respondents was generated after the questionnaire had been approved for data collection by the main supervisor of the current study. The researcher randomly selected the construction professional companies practising in Gauteng to send the questionnaires to. The questionnaires were distributed to the respondents via email and hand delivered, but permission was asked first to send through emails to their employees and distributed on site and in the offices. When completed they were sent back by email and others physically collected from the respondents by the researcher.

6.9 INSTRUMENT OF DATA COLLECTION

The researcher chose to use a questionnaire as an instrument of collecting data for this research. Burns and Grove (1993:368) define a questionnaire as a printed self-report form designed to draw information that can be obtained through the written responses of the subject. To evaluate the causes and effects of the engineering skills’ shortages in the construction industry of South Africa as well as methods used to minimise these, data was collected using questionnaires. The questionnaires are structured as closed-ended
questionnaires where the respondents are given options related to research topic determined by the researcher as these are easier to administer and analyse.

Anonymity of the respondents’ responses was assured. A questionnaire was used which consists of the following three main parts (see appendix a):

Section A

The questionnaire requested essential information about the participants’ personal and academic attributes. Those attributes include: age, gender, qualification, then number of projects they have been involved in and the level of experience they have.

Section B

The questions in section B included items to gather data about the cause of the engineering skills’ shortages in the construction industry. The scale of measuring is a five point Likert-type with the following response choices as a part of the instrument: 1 = strongly disagree (SD), 2 = disagree (D), 3 = neutral (N), 4 = agree (A) and 5 = strongly agree (SA).

Section C

Section C examines the effect the engineering skills’ shortage has on South African construction industry. The scale of measuring the effects is a five-point Likert-type with the following response choices as a part of the instrument: 1 = strongly disagree (SD), 2 = disagree (D), 3 = neutral (N), 4 = agree (A) and 5 = strongly agree (SA).

Section D

Section D comprised the measures that can be used to reduce the engineering skills’ shortage in the construction industry. The scale of measuring to assess the strategies is a five point Likert-type with the following response choices as a part of the instrument: 1 = strongly disagree (SD), 2 = disagree (D), 3 = neutral (N), 4 = agree (A) and 5 = strongly agree (SA).

Instructions and guidelines were attached to the questionnaires to guide the respondents on how to answer the questionnaires.

Out of the two hundred copies of the questionnaire sent out, one hundred and fifty-three were returned back which represents a 77 per cent response rate. These formed the basis of
this study as summarised in Table 6.1 below. The result of a survey is adequate for analysis on the assertion by Moser and Kalton (1971).

Table 6.1: Questionnaire survey

<table>
<thead>
<tr>
<th>Survey Responses</th>
<th>Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Questionnaires sent out</td>
<td>200</td>
</tr>
<tr>
<td>Questionnaires returned</td>
<td>153</td>
</tr>
<tr>
<td>Usable questionnaires</td>
<td>153</td>
</tr>
<tr>
<td>Usable response rate (per cent)</td>
<td>76.5 per cent</td>
</tr>
</tbody>
</table>

6.10 MEAN ITEM SCORE (MIS)

A five-point Likert scale was used to determine the causes and effects of engineering skills’ shortages in construction industry of Gauteng Province in South Africa as well as a consideration of the methods of minimising these with respect to the identified factors from the reviewed literature. The adopted scales were as follows:

1. = Strongly disagree
2. = Disagree
3. = Neutral
4. = Agree
5. = Strongly agree

The five-point scale was transformed to a mean item score (MIS) for each of the factors of causes, effects and methods of minimising factors of engineering skills’ shortages as assessed by the respondents. The indices were then used to determine the rank of each item. The ranking made it possible to cross-reference the relative importance of the items as perceived by the respondents. This method was used to analyse the data collected from the questionnaire survey.
The computation of the relative mean item score (MIS) was calculated from the total of all weighted responses and then relating it to the total responses on a particular aspect. This was based on the principle that respondents’ scores on all the selected criteria, considered together, are the empirically determined indices of relative importance. The index of MIS of a particular factor is the sum of the respondents’ actual scores (on the five-point scale) given by all the respondents’ as a proportion of the sum of all maximum possible scores on the five-point scale that all the respondents could give to that criterion. A weighting was assigned to each response ranging from one to five for the responses of ‘strongly disagree’ to ‘strongly agree’. This is expressed mathematically below. The mean item score (MIS) was calculated for each item as follows,

\[
\text{MIS} = \frac{1n_1 + 2n_2 + 3n_3 + 4n_4 + 5n_5}{\sum N} \quad \text{Equation 1.0}
\]

where

\[n_1 = \text{the number of respondents for extremely unlikely or strongly disagree,}\]
\[n_2 = \text{the number of respondents for unlikely of disagree,}\]
\[n_3 = \text{the number of respondents for neutral},\]
\[n_4 = \text{the number of respondents for likely or agree,}\]
\[n_5 = \text{the number of respondents for extremely likely or strongly agree, and}\]
\[N = \text{total number of respondents}\]

After mathematical computations, the criteria are then ranked in descending order of their mean item score (from the highest to the lowest).

6.11 DATA ANALYSIS

Data was analysed based on the information received from the respondents. Data presentation and analysis made use of frequency distributions and percentages of all the respondents. Frequency tables were drawn and from these the data was presented in pie chart diagrams, bar graphs and tables.
6.12 LIMITATION OF THE STUDY

This research assessment was only based on the construction professionals in Gauteng Province in South Africa, with the respondents being architects, quantity surveyors, civil engineers, construction managers, construction project managers, project managers and other professionals who are involved in construction projects in Gauteng Province, South Africa. This study only determined factors responsible for effects the engineering skills’ shortages have on the South African construction industry and further proposed measures to reduce the current engineering skills’ shortages in South African construction industry.

6.13 ETHICAL CONSIDERATION

A written cover letter of permission to carry out this research obtained from the University of Johannesburg, Department of Construction Management and Quantity Surveying, Doornfontein Campus was distributed along with the questionnaires to all participants, giving an explanation of the purpose of the study. The participation in the study was voluntary, participants were free to withdraw at any time and the participants were assured that they would remain anonymous. All information gathered remained strictly confidential. Respondents to the questionnaire had the right not to answer questions that they felt were not appropriate without any coercion.

6.14 CONCLUSION

In this chapter, the research methodology used for the study was described, including the population, sample size, data collection instruments as well as strategies used to ensure ethical standards. The next chapter of this study presents the data analysis and discussion.
CHAPTER SEVEN

DATA ANALYSIS AND DISCUSSIONS OF THE DATA

7.1 INTRODUCTION

This chapter deals with the discussion of the data collected from the questionnaires, which were distributed to research respondents, who included architects, quantity surveyors, civil engineers, construction project managers, construction managers and other professionals within the built environment in the Gauteng Province, South Africa. An analysis of the data and an interpretation of the results were obtained from the questionnaire survey using a quantitative collection method. Data was presented clearly with the aid of tables, percentages and graphs, where possible. A total number of 200 questionnaires were distributed to randomly selected respondents. A total of 153 questionnaires were returned reflecting a 76.5 per cent response rate.

The first section of the questionnaire reviewed the background of the respondents. The second portion examined their perceptions of the causes of the engineering skills’ shortages within the South African construction industry. The third section evaluated the effects of the engineering skills’ shortages on the South Africa construction industry, and lastly the fourth section explored the measures to minimise engineering skills’ shortages in Gauteng, South African construction industry.

7.2 DATA ANALYSIS

7.2.1 Section A: Respondents’ background and information

Figure 7.1 reveals that out of the 153 respondents 69.3 per cent were male, while 30.7 were female.
Figure 7.1: Respondents’ gender

Figure 7.2 shows findings relating to the respondents’ age group. The figure revealed that 2.0 per cent of the respondents were in the age group of 21-25 years old, 22.2 per cent of the respondents were in the age group of 26-30 years old, 22.9 per cent of the respondents were in the age group of 31-35 years old, 12.4 per cent of the respondents were in the age group of 36-40 years old, 14.4 per cent of the respondents were in the age group of 41-45 years old, 6.5 per cent of the respondents were in the age group of 46-50 years old, 9.2 per cent of the respondents were in the age group of 51-55 years old, and only 10.5 per cent of the respondents were older than 55 years.

Figure 7.2: Respondents’ age category

Figure 7.3 shows the respondents’ ethnicity: it revealed that 73.9 per cent of the respondents were African, 19.0 per cent of the respondents were white and 7.2 per cent of the respondents were coloured.
Figure 7.3: Respondents’ ethnicity.

Figure 7.4 indicates the respondents’ working experience in the construction industry. It revealed that 39.9 per cent of the respondents had four to five years of experience, 24.2 per cent of the respondents had nine to fourteen years of experience, 12.4 per cent of the respondents had fourteen to nineteen years of experience, 12.4 per cent of the respondents had nineteen to twenty-four years of experience and only 11.1 per cent of the respondents had more than twenty-four years of experience.

Figure 7.4: Respondents’ years of experience

Figure 7.5 represents the highest educational qualification that the respondents’ have attained and it showed that 3.3 per cent had attained grade 11 or lower (Std 9 or lower), 5.2 per cent had grade 12 (Matric, Std 10), 31.4 per cent had a post-matric diploma or certificate, 32.7 per cent had baccalaureate degree (s) and 27.5 per cent had a post-graduate degree(s).
Figure 7.5: Respondents’ educational qualification

Figure 7.6 displays the type of company the respondents worked for. It revealed that 5.2 per cent worked for a client, 0.7 per cent worked for a private corporate client (e.g. banks), 32.0 per cent were private sector consultants, 43.1 per cent worked for a private sector contractor and 19.0 percent worked for the public sector (government).

Figure 7.6: Respondents’ company type

Figure 7.7 displays the level of employment of the respondents. It shows that 13.7 per cent of the respondents’ are at a junior level, 31.4 per cent of the respondents’ are at an intermediate level, 28.8 per cent of the respondents’ hold senior positions and 26.1 per cent of the respondents are managers.
Figure 7.7: Respondents level of employment

Figure 7.8 portrays the number of years of respondents’ involvement in construction projects. It revealed that 0.7 per cent had not been involved in any projects, 22.2 per cent had been involved in one to two projects, and 30.7 per cent in three to four projects, 22.9 per cent in five to six projects, 9.8 per cent in seven to eight projects and 13.7 per cent had been involved in more than eight projects.

Figure 7.8: Respondents’ construction projects involvement

Figure 6.6 represents the sampled respondents’ occupations. The results showed that 6.6 per cent were architects, 28.3 per cent were quantity surveyors, 6.6 per cent were structural engineers, 13.8 per cent were electrical engineers, 7.2 per cent were mechanical engineers, 8.6 per cent were civil engineers, 6.6 per cent were project managers, 7.9 per cent were construction managers, another 7.9 per cent work as construction project managers and the remaining 6.6 per cent were others: that include health and safety officers and health and safety representatives.
7.2.2 Section B: Causes of engineering skills’ shortages in the South African construction industry

Table 7.1 reveals the respondents’ ranking of the causes of the engineering skills’ shortages in the construction industry in Gauteng Province of South Africa. It reveals that retirement of experienced engineers was ranked first with a mean item score (MIS) of 3.67 and standard deviation (SD) = 1.313; low pass rate in STEM (Science, technology, engineering and mathematics) was also ranked first with a MIS of 3.67 and SD = 1.303; poor career guidance in subject choices was ranked second with a MIS of 3.61 and SD = 1.284; lack of experiential training opportunities was ranked third with a MIS of 3.58 and SD = 1.31; lack of mentors for new graduates was ranked fourth with a MIS of 3.47 and SD = 1.271; lack of government support for tertiary education was ranked fifth with a MIS of 3.46 and SD = 1.257; immigration of experienced engineers was ranked sixth with a MIS of 3.33 and SD = 1.293; and low remuneration for engineering professionals was ranked seventh with a MIS of 3.30 and SD = 1.37. In addition, growth of new industries into different regions with a different skills’ base was ranked eighth with a MIS of 3.23 and SD = 1.320; poor working conditions was ranked ninth with a MIS of 3.20 and SD = 1.252; lack of industry-specific qualifications and certifications in terms of professionals were ranked tenth with a MIS of 3.16 and SD = 1.29; number of graduate drop-outs was ranked eleventh with a MIS of 3.12 and SD = 1.323; political instability was ranked twelfth with a MIS of 3.11 and SD = 1.301; relocation of new industries into different regions with a different skills base was ranked thirteenth with a MIS of 3.07 and SD = 1.255; negative perception of the industry was ranked fourteenth with a MIS of 2.99 and SD = 1.230; affirmative action was ranked fifteenth with a MIS of 2.96 and SD of 1.317; cyclical...
economy shifts was ranked sixteenth with a MIS of 2.94 and SD = 1.253 and finally, rising crime was ranked seventeenth with a MIS of 2.82 and SD = 1.300.

Table 7.1: Causes of engineering skills’ shortages in the construction industry

<table>
<thead>
<tr>
<th>Causes of engineering skills’ shortages</th>
<th>MIS</th>
<th>SD</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retirement of experienced engineers</td>
<td>3.67</td>
<td>1.313</td>
<td>1</td>
</tr>
<tr>
<td>Low pass rate in STEM (Science, technology, engineering and mathematics)</td>
<td>3.67</td>
<td>1.303</td>
<td>1</td>
</tr>
<tr>
<td>Poor career guidance in subject choices</td>
<td>3.61</td>
<td>1.284</td>
<td>2</td>
</tr>
<tr>
<td>Lack of experiential training opportunities</td>
<td>3.58</td>
<td>1.310</td>
<td>3</td>
</tr>
<tr>
<td>Lack of mentors for new graduates</td>
<td>3.47</td>
<td>1.271</td>
<td>4</td>
</tr>
<tr>
<td>Lack of government support for tertiary education</td>
<td>3.46</td>
<td>1.257</td>
<td>5</td>
</tr>
<tr>
<td>Immigration of experienced engineers</td>
<td>3.33</td>
<td>1.293</td>
<td>6</td>
</tr>
<tr>
<td>Low remuneration for engineering professionals</td>
<td>3.30</td>
<td>1.371</td>
<td>7</td>
</tr>
<tr>
<td>Growth of new industries into different regions with a different skills’ base</td>
<td>3.23</td>
<td>1.320</td>
<td>8</td>
</tr>
<tr>
<td>Poor working conditions</td>
<td>3.2</td>
<td>1.252</td>
<td>9</td>
</tr>
<tr>
<td>Lack of industry-specific qualifications and certifications in terms of professionals</td>
<td>3.16</td>
<td>1.29</td>
<td>10</td>
</tr>
<tr>
<td>Number of graduate drop – outs</td>
<td>3.12</td>
<td>1.323</td>
<td>11</td>
</tr>
<tr>
<td>Political instability</td>
<td>3.11</td>
<td>1.301</td>
<td>12</td>
</tr>
<tr>
<td>Relocation of new industries into different regions with a different skills’ base</td>
<td>3.07</td>
<td>1.255</td>
<td>13</td>
</tr>
<tr>
<td>Negative perception of the industry</td>
<td>2.99</td>
<td>1.230</td>
<td>14</td>
</tr>
<tr>
<td>Affirmative action</td>
<td>2.96</td>
<td>1.317</td>
<td>15</td>
</tr>
<tr>
<td>Cyclical economy shifts</td>
<td>2.94</td>
<td>1.253</td>
<td>16</td>
</tr>
<tr>
<td>Rising crime</td>
<td>2.82</td>
<td>1.300</td>
<td>17</td>
</tr>
</tbody>
</table>

MIS = Mean item score; STD = Standard deviation; R = rank

### 7.2.3 Section C: Effects of engineering skill’s shortages in the South African construction industry

Table 7.2 reveals the respondents’ ranking of the effects of the engineering skills’ shortages on the construction industry in the Gauteng Province of South Africa. It shows that difficulties in recruiting was ranked first with a MIS of 3.89 and SD = 1.104; poor decision making due to not having the right skilled people was ranked second with a MIS of 3.61 and SD = 1.319; lack of quality relevance of training received was ranked third with a MIS of 3.58 and SD = 1.281; low employment rate was also ranked third with a MIS of 3.58 and SD 1.217; inflated costs because of sourcing skills from abroad was ranked fourth with a MIS of 3.52 and SD = 1.262; lack of creative skilled engineers in SA due to increased use of overseas engineers was also ranked fourth with a MIS of 3.52 and SD = 1.30; skill deficiency was ranked fifth with a MIS of 3.48 and SD = 1.267; poor quality delivery was ranked sixth with a MIS of 3.47 and SD = 1.342; lack of innovative technology changes within the industry was ranked seventh with a MIS of 3.44 and SD = 1.277; and poor performance in the construction industry was ranked eighth with MIS of 3.41 and SD = 1.308. In addition emigration was ranked ninth with a MIS of 3.36 and SD = 1.223; damage to the SA economy was ranked tenth with a MIS of 3.33 and SD = 1.395; poor working environments and conditions was ranked eleventh with a MIS of 3.32 and SD = 1.239; construction industry unable to grow and expand was ranked twelfth with a MIS of 3.29 and SD = 1.245; South Africa becoming a less attractive place to invest in was ranked thirteenth with a MIS of 3.27 and SD = 1.392; poor quality of workmanship was ranked fourteenth with a MIS of 3.21 and SD = 1.413 and finally, higher project costs was ranked the fifteenth with MIS of 2.99 and SD = 1.254.
Table 7.2: Effects of the engineering skills’ shortages on the South African construction industry

<table>
<thead>
<tr>
<th>Effects of engineering skills’ shortages on the construction industry</th>
<th>MIS</th>
<th>SD</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Difficulties in recruiting</td>
<td>3.89</td>
<td>1.104</td>
<td>1</td>
</tr>
<tr>
<td>Poor decision making due to not having the right skilled people</td>
<td>3.61</td>
<td>1.319</td>
<td>2</td>
</tr>
<tr>
<td>Lack of quality relevance of training received</td>
<td>3.58</td>
<td>1.281</td>
<td>3</td>
</tr>
<tr>
<td>Low employment rate</td>
<td>3.58</td>
<td>1.217</td>
<td>3</td>
</tr>
<tr>
<td>Inflated costs because of sourcing skills’ from abroad</td>
<td>3.52</td>
<td>1.262</td>
<td>4</td>
</tr>
<tr>
<td>Lack of creative skilled engineers in SA due to increased use of overseas engineers</td>
<td>3.52</td>
<td>1.303</td>
<td>4</td>
</tr>
<tr>
<td>Skills’ deficiency</td>
<td>3.48</td>
<td>1.267</td>
<td>5</td>
</tr>
<tr>
<td>Poor quality delivery</td>
<td>3.47</td>
<td>1.342</td>
<td>6</td>
</tr>
<tr>
<td>Lack of innovative technology changes within the industry</td>
<td>3.44</td>
<td>1.277</td>
<td>7</td>
</tr>
<tr>
<td>Poor performance in the construction industry</td>
<td>3.41</td>
<td>1.308</td>
<td>8</td>
</tr>
<tr>
<td>Emigration</td>
<td>3.36</td>
<td>1.223</td>
<td>9</td>
</tr>
<tr>
<td>Damage to the SA economy</td>
<td>3.33</td>
<td>1.395</td>
<td>10</td>
</tr>
<tr>
<td>Poor working environments and conditions</td>
<td>3.32</td>
<td>1.239</td>
<td>11</td>
</tr>
<tr>
<td>Construction industry unable to grow and expand</td>
<td>3.29</td>
<td>1.245</td>
<td>12</td>
</tr>
<tr>
<td>South Africa becoming a less attractive place to invest in</td>
<td>3.27</td>
<td>1.392</td>
<td>13</td>
</tr>
<tr>
<td>Poor quality of workmanship</td>
<td>3.21</td>
<td>1.413</td>
<td>14</td>
</tr>
<tr>
<td>Higher project costs</td>
<td>2.99</td>
<td>1.254</td>
<td>15</td>
</tr>
</tbody>
</table>
MIS = Mean item score; STD = Standard deviation; R = rank

7.2.4 Section D: Measures of minimising engineering skill’s shortages into South African construction industry

Table 7.3 reveals the respondents’ ranking of measures of minimising engineering skills’ shortages in the construction industry in Gauteng. It shows that higher participation in science, engineering and mathematics subjects at secondary level was ranked first with a MIS of 4.1 and SD = 0.968; offering career exhibitions to secondary schools was ranked first also with a MIS of 4.1 and SD = 0.872; providing opportunities for on-the-job training was ranked second with a MIS of 3.89 and SD = 1.158; improved working conditions was ranked third with a MIS of 3.78 and SD = 1.219; industry professionals to share their knowledge was ranked fourth with a MIS of 3.76 and SD = 1.303; companies to focus on enhancing existing skills’ in their businesses was ranked fifth with a MIS of 3.74 and SD = 1.24, introducing training programs was ranked sixth with MIS of 3.72 and SD = 1.349; and use of experienced engineers that retired for mentoring programs was ranked seventh with MIS of 3.71 and SD = 1.301. In addition, higher remuneration scales for engineering professionals was ranked eighth with a MIS of 3.69 and SD = 1.227; employers to collaborate with educators to identify the skills needed to map career pathways from entry level to middle skills jobs and beyond was ranked ninth with a MIS of 3.64 and SD = 1.306; companies to provide additional training and development to existing staff was ranked tenth with a MIS of 3.61 and SD = 1.247; positive and good impression of the industry was also ranked tenth with a MIS of 3.61 and SD = 1.226, private sectors to invest in secondary schools was ranked eleventh with a MIS of 3.59 and SD = 1.269; higher market related salaries was ranked the twelfth with a MIS of 3.48 and SD = 1.343 and finally, government to subsidise full tertiary education was ranked thirteenth with a MIS of 3.42 and SD = 1.408.

Figure 7.3: Measures of minimising engineering skills’ shortages in the construction industry

<table>
<thead>
<tr>
<th>Measures of minimising engineering skills’ shortages in the construction industry</th>
<th>MIS</th>
<th>SD</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher participation in science, technology, engineering and</td>
<td>4.1</td>
<td>0.968</td>
<td>1</td>
</tr>
</tbody>
</table>

67
<table>
<thead>
<tr>
<th>Mathematics subjects at secondary level</th>
<th>MIS</th>
<th>STD</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offer career exhibitions to secondary schools</td>
<td>4.1</td>
<td>0.872</td>
<td>1</td>
</tr>
<tr>
<td>Providing opportunities for on the job training</td>
<td>3.89</td>
<td>1.158</td>
<td>2</td>
</tr>
<tr>
<td>Improved working conditions</td>
<td>3.78</td>
<td>1.219</td>
<td>3</td>
</tr>
<tr>
<td>Industry professionals to share their knowledge</td>
<td>3.76</td>
<td>1.303</td>
<td>4</td>
</tr>
<tr>
<td>Companies to focus on enhancing existing skills’ in their businesses</td>
<td>3.74</td>
<td>1.24</td>
<td>5</td>
</tr>
<tr>
<td>Introducing training programs</td>
<td>3.72</td>
<td>1.349</td>
<td>6</td>
</tr>
<tr>
<td>Use of experienced engineers who retired for mentoring programs</td>
<td>3.71</td>
<td>1.301</td>
<td>7</td>
</tr>
<tr>
<td>Higher remuneration scales for engineering professionals</td>
<td>3.69</td>
<td>1.227</td>
<td>8</td>
</tr>
<tr>
<td>Employers to collaborate with educators to identify the skills’ needed to map career pathways from entry level to middle skills’ jobs and beyond</td>
<td>3.64</td>
<td>1.306</td>
<td>9</td>
</tr>
<tr>
<td>Companies to provide additional training and development to existing staff</td>
<td>3.61</td>
<td>1.247</td>
<td>10</td>
</tr>
<tr>
<td>Positive and good impression of the industry</td>
<td>3.61</td>
<td>1.226</td>
<td>10</td>
</tr>
<tr>
<td>Private sectors to invest in secondary schools</td>
<td>3.59</td>
<td>1.269</td>
<td>11</td>
</tr>
<tr>
<td>Higher-market related salaries</td>
<td>3.48</td>
<td>1.343</td>
<td>12</td>
</tr>
<tr>
<td>Government to subsidise full tertiary education</td>
<td>3.42</td>
<td>1.408</td>
<td>13</td>
</tr>
</tbody>
</table>

MIS = Mean item score; STD = Standard deviation; R = rank
7.3 CONCLUSION

Data collected from the structured questionnaire that were randomly distributed to the built environment professionals such as architects, quantity surveyors, structural engineers, electrical engineers, mechanical engineers, civil engineers, project managers, construction managers and construction project managers in Gauteng, South Africa was presented and analysed in this chapter. The next chapter will discuss the findings of the research analysis relating to the research questions and the research objectives that were postulated in Chapter one. The primary reason for this is to make sure whether the research objectives were met.
CHAPTER EIGHT

DISCUSSION OF FINDINGS

8.1 CHAPTER INTRODUCTION

Chapter 8 discusses the findings from the research analysis in relation to the research questions. The findings are further discussed in relation to the reviewed literature in chapters 2, 3, 4 and 5. This is with the view to ascertaining whether the defined research problems have been ‘answered’ from the findings’ analysis in Chapter 7. Results have been presented in relation to the research question and the relevant data as required. This chapter also presents conclusions based on the research objectives and finally gives a general research conclusion.

8.2 BIOGRAPHICAL DATA

This section examines the background information of the respondents relating to their demographical data, which mainly included gender, age group, ethnicity, years of experience, highest educational qualification, type of organisation they work for, level of employment, number of construction projects they are involved in and their job title.

8.2.1 Biographical data results

The results from the 153 usable questionnaires revealed that the majority of the respondents were males with 69.3 per cent indicating that the construction industry is still male dominated. Majority of the respondents were between the ages of 31-35 years (22.9 per cent); followed by the age between 26 -30 years (22.2 per cent); then 41-45 years (14.4 per cent); between the age of 36 -40 years of age (12.4 per cent); older than 55 years (10.5 per cent) age between 51 – 55 years (9.2 per cent); between the age of 46-50 year (6.5 per cent); and between 21-25 years of age (2.0 per cent). Findings relating to ethnicity of the respondents showed that the majority of the respondents were African (73.9 per cent) followed by white (19.0 per cent) and finally coloured (7.2 per cent). Findings relating to years of experience of the respondents revealed that 39.9 per cent had between 4-9 years; 24.2 per cent had between 9-14 years, 12.4 per cent had between 14-19 years of experience and 12.4 per cent had between 19-24 years. A total of 11.1 per cent had more than 24 years of experience showed. Further results showed that the respondents’ highest education started with grade 11 or lower (Std 9 or lower) with 3.3 per cent, grade 12 (matric, Std 10) with 5.2 per cent, post-matric diploma or
certificate with 31.4 per cent, baccalaureate degree(s) with 32.7 per cent and post-graduate degree(s) with 27.5 per cent.

Findings relating to the type of the organisation the respondents’ are working for, revealed that the majority of the sampled respondents were working for the private sector contractors (43.1 per cent); followed by private sector consultant (32.0 per cent) then 19.0 per cent with the public sector (government); 5.2 per cent are client; and 0.7 per cent are with the private corporate clients (e.g. banks). Regarding findings relating to respondents’ construction projects they were currently involved in, results showed that 30.7 per cent of the respondents’ were involved in between 3-4 projects; 22.9 per cent were involved in between 5-6 projects; 22.2 per cent of the respondents were involved in between 1-2 projects; 13.7 per cent of the respondents were involved in more than 8 projects; 7.8 per cent were between 7-8 projects and only 0.7 were not involved in any projects.

In addition, the results related to the respondents’ job title revealed that 28.1 per cent of the respondents’ were quantity surveyors, 13.7 per cent of the respondents were electrical engineers, 8.5 per cent were civil engineers, 7.8 per cent of the respondents were construction managers, another 7.8 per cent of the respondents were construction project managers, 7.2 per cent of the respondents worked as mechanical engineers and 6.5 per cent of the respondents were architect. Another 6.5 per cent of the respondents were structural engineers, 6.5 per cent of the respondents were project managers and another 6.5 per cent of the respondents have other job titles in the construction industry.

8.3 RESEARCH QUESTION 1

What are the causes of the engineering skills’ shortages in the South African construction industry?

8.3.1 Relevant data

For a thorough evaluation of the causes of the engineering skills’ shortages in the South African construction industry, only data relevant to research Question 1 were used.

8.3.2 Findings

The findings were established on the ranking (R) with use of the calculated standard deviation (SD) and mean item score (MIS) for the listed causes of the engineering skills’ shortages in the
construction industry. It was observed that the most dominant causes included retirement of experienced engineers with MIS of 3.67, SD of 1.313 and R of 1; low pass rate in STEM (Science, technology, engineering and mathematics) with MIS of 3.67, SD of 1.303 and R of 1; poor career guidance in subject choices with MIS of 3.61, SD of 1.284 and R of 2; lack of experiential training opportunities with MIS of 3.58, SD of 1.310 and R of 3; lack of mentors for new graduates with MIS of 3.47, SD of 1.257 and R of 4; lack of government support for tertiary education with MIS of 3.46, SD of 1.257 and R of 5; immigration of experienced engineers with MIS of 3.33, SD of 1.293 and R of 6; and low remuneration for engineering professionals with MIS of 3.30, SD of 1.371 and R of 7.

8.3.3 Discussion

These findings were similar to findings by Dawes and Rasmussen (2013) and the Australian Mathematical Sciences Institute (2012), where poor career guidance in subject choices and pass rates or number of students taking the STEM (Science, technology, engineering and mathematics) subjects were among the highest factors of the causes of the engineering skills’ shortages. Ottawa (2010) and Pillai (2015) also indicated the retirement of experienced engineers as one of the causes of the engineering skills’ shortages in the construction industry as well. Similarly, the results also agree with those of Anekwe (2003) and Suleymay (2008), namely emigration of experienced engineers is also a major cause of the engineering skills’ shortages. Furthermore, the results in the current study agree with Osman (2011) who indicated low remuneration for engineering professionals as a cause of the engineering skills’ shortages as well. However, the results were not in agreement with the study by Bailey (2003) where affirmative action was identified as the cause of the engineering skills’ shortages. Furthermore, the results in the current study did not agree with the studies by Barry and Jordaan (2009), Alam and Hoque (2010) and Fourier (2006) where rising crime and political instability were the causes of the engineering skills’ shortages.

8.3.4 Implication of findings

Retirement of experienced engineers, the low pass rate in STEM subjects, poor career guidance in subject choices, a lack of experiential training opportunities, a lack of mentors for new graduates and a lack of government support for tertiary education were indicated as the major causes of the engineering skills’ shortages in the construction industry. This implies that South Africa should invest in the matter of skills’ shortages in order to provide more employment opportunities to its citizens and physical and social infrastructure to the economy.
of South Africa. However infrastructure development is vital to a country’s economic development and prosperity and ensures the effective functioning of the South African economy and without appropriate engineering skills’ there will be no infrastructure development and the economy of South Africa will be in a bad state. This implies that having more approximately trained engineers who know what to in the industry would result in the healthy functioning of the economy of South Africa.

8.4. RESEARCH QUESTION 2

What are the effects of the engineering skills’ shortages to the South African construction industry?

8.4.1 Relevant data

For a thorough evaluation of the effects of the engineering skills’ shortages to the South African construction industry, only data pertinent to research Question 2 were used.

8.4.2 Findings

Based on the ranking (R) with the use of the calculated standard deviation and mean item score (MIS) for the listed effects of the engineering skills’ shortages to the construction industry in Gauteng, it was found that the most preeminent factor was difficulties in recruiting with a MIS of 3.89, SD of 1.104, R of 1; poor decision making due to not having the right skilled people with a MIS of 3.61, SD of 1.319, R of 2; lack of quality relevance of training received with a MIS of 3.58, SD of 1.281, R of 3; low employment rate with a MIS of 3.58, SD of 1.217, R of 4; and inflation costs because of sourcing skills from abroad with a MIS of 3.52, SD of 1.262, R of 4; and a lack of creative skilled engineers in SA due to increased use of overseas engineers with a MIS of 3.52, SD of 1.303, R of 4. In addition, skills deficiency with a MIS of 3.48, SD of 1.367, R of 5; poor quality delivery with a MIS of 3.47, SD of 1.342, R of 6; lack of innovative technology changes within the industry with a MIS of 3.44, SD of 1.277, R of 7; poor performance in the construction industry with a MIS of 3.41 of SD of 1.308, R of 8; emigration with a MIS of 3.36, SD of 1.223, R of 9; damage to the SA economy with a MIS of 3.330, SD of 1.395, R of 10; and poor working environments and conditions with a MIS of 3.32, SD of 1.239, R of 11 were further effects on the construction industry.

Furthermore construction industry being unable to grow and expand with a MIS of 3.29, SD of 1.245, R of 12; South Africa becoming less attractive place to invest in with a MIS of 3.27, SD
8.4.3 Discussion

The findings were in agreement with the survey conducted by Lawless (2005) which revealed that there is lack of quality relevance to the training received or no experiential training for graduates; hence they are unable to graduate. The findings were also in agreement with the study conducted by the Institution of Engineering and Technology which revealed that engineering companies are having difficulties in recruiting suitable candidates to meet the requirements.

8.4.4 Implication of Findings

From the above findings it is evident that difficulties in recruiting, poor decision making due to not having the right skilled people, lack of quality relevance of training received, low employment rate, inflated costs because of sourcing skills’ from abroad, lack of creative skilled engineers in SA due to increased use of overseas engineers and skills deficiency are amongst the effects of the engineering skills’ shortage on the construction industry of South Africa. The construction industry is regarded as one of the supporting pillars of the South African economy. Given the factors from the findings there will be serious delays in projects and low levels of participation from the workers. However, some of the bigger projects will be badly constructed and take too long to be completed. This means that the quality of standard and business practices is going to be questionable.

8.5. RESEARCH QUESTION 3

What measures can be taken to minimise the engineering skills’ shortages in the South African construction industry?

8.5.1. Relevant data

To identify sufficient steps to be taken to minimise the engineering skills’ shortage in South African construction industry, only data relevant to research Question 3 were used.
8.5.2 Findings

The findings were based on R with the use of the calculated SD and MIS for the listed measures of minimising the engineering skills’ shortages in the South African construction industry. Results showed that the most effective measures include the following: higher participation in science, technology, engineering and mathematics subjects at secondary level with a MIS of 4.1, SD of 0.968, R of 1; followed by offering career exhibitions to secondary schools with a MIS of 4.1, SD of 0.872, R of 1; providing opportunities for on-the-job training with a MIS of 3.89, SD of 1.158, R of 2; improved working conditions with a MIS of 3.78, SD of 1.219, R of 3; industry professionals to share their knowledge with a MIS of 3.76, SD of 1.303, R of 4; companies to focus on enhancing existing skills in their business with a MIS of 3.74, SD of 1.24, R of 5; introducing training programs with a MIS of 3.72, SD of 1.349, R of 6; use of experienced engineers that retired for mentoring programs with a MIS of 3.71, SD of 1.301, R of 7. In addition, higher remuneration scales for engineering professionals with a MIS of 3.69, SD of 1.227, R of 8; employers to collaborate with educators to identify the skills needed to map career pathways from entry level to middle skills jobs and beyond with a MIS of 3.64. SD of 1.309, R of 9; companies to provide additional training and development to existing staff with a MIS of 3.61 SD of 1.247, R of 10; positive and good impression of the industry with a MIS of 3.61, SD of 1.226, R of 10; private sectors to invest in secondary schools with a MIS of 3.59, SD of 1.269, R of 11; higher market-related salaries with a MIS of 3.48, SD of 1.343, R of 12 and finally, government to subsidise full tertiary education with MIS of 3.42, SD of 1.408 and R of 13 were additional measures for the minimising the effects of the engineering skills’ shortages.

8.5.3 Discussion

The findings agreed with the study conducted by Professor James (2015) and findings from the BCA (2012) which revealed that the industry professionals must provide opportunities for on-the-job training and higher participation in science, technology, engineering and mathematics subjects to overcome the challenges of the engineering skills’ shortages. The findings also agreed with the study conducted by Anet (2011) relating to introducing training programs that could aid in reducing the engineering skills’ shortages we are faced with.
8.5.4 Implication of Findings

Encouraging higher participation in science, technology, engineering and mathematics subjects at secondary level, offering career exhibitions, providing opportunities for on-the-job training, industry professionals sharing their knowledge and companies focusing on enhancing existing skills’ in their business were indicated as some of the ways to use to minimise the engineering skills’ shortages in the construction industry. There is a need to improve the work experience available to undergraduates and to newly graduating engineers as well. It is incumbent upon the industry to raise awareness and knowledge of engineering careers through providing with more direct experience of the construction industry. South Africa needs to develop enough skills’ to ensure proper maintenance and upgrading of the existing infrastructure. Participation in science, technology, engineering and mathematics (STEM) subjects requires the support of all sectors as it affects everyone in South Africa. STEM education is one of the critical issues in South Africa and it is essential for the growth and development of the economy.

8.6 CONCLUSION

In this chapter the findings related to the research questions of the current study were explained and discussed. Also, for a throughout evaluation of each research question, only data relevant to research question were used to answer them. In addition, a comparison of the current findings with previous findings from explored literature in Chapters 2, 3, 4, 5 was done in order to show any differences between engineering skills’ shortages in the construction industry in the past and in the present. The next chapter will present conclusions and recommendations based on the primary purpose of the study.
CHAPTER 9

CONCLUSIONS AND RECOMMENDATIONS

9.1 INTRODUCTION

The primary purpose of the current research study was to investigate the causes of the engineering skills’ shortages, the effects of the engineering skills’ shortages on the South African construction industry and the measures that can be taken to minimise engineering skills’ shortages in the South African construction industry. A sample size of 153 built environment professionals was used to obtain the analysed findings in Chapters 7 and 8. In this chapter of the study, the conclusion and recommendations of the research study are presented and discussed according to the objectives of the study. The objectives of the study were as follows:

- To determine the causes of the engineering skills’ shortages in the South African construction industry;
- To analyse the effects of engineering skills’ shortages on the South African construction industry; and
- To establish measures of minimising the engineering skills’ shortages in the South African construction industry.

The following section will indicate how the above-mentioned objectives have been met.

9.2 RESEARCH OBJECTIVE 1

The first research objective was to determine the causes of the engineering skills’ shortages in the South African construction industry

Literature revealed that the major causes of engineering skills’ shortages in the construction industry include: poor career guidance in subject choices, retiring workforce, negative perception of the industry, poor pass rate in STEM subjects (science, technology, engineering and mathematics), low remuneration for engineering professionals, lack of experiential training opportunities, the number of graduate drop-outs, political instability, lack of government support for tertiary education and the poor education system as causes of the engineering skills’ shortages amongst others.
The findings from the questionnaires survey results obtained from the respondents’ showed that retirement of experienced engineers, the low pass rate in STEM subjects (science, technology, engineering and mathematics), poor career guidance in subject choices, lack of experiential training opportunities, lack of mentors for new graduates, lack of government support for tertiary education, emigration of experienced engineers, and low remuneration for engineering professionals were the major causes of the engineering skills’ shortages in the construction industry in Gauteng as revealed by the questionnaire survey. Hence the research objective was achieved from both literature review and from the structured questionnaire.

9.3 RESEARCH OBJECTIVE 2

The second research objective of the current study was to analyse the effects of engineering skills’ shortages on the South African construction industry.

Literature on the effects of engineering skills’ shortages revealed that skills’ deficiency, lack of innovative technological changes within the industry, lack of quality relevance of the training received, difficulties in recruiting right candidates for the job, emigration, a negative effect on the quality of higher education, poor working environment and conditions, damage to the economy, difficulties in recruiting, and poor quality delivery were among the effects of the engineering skills’ shortages on the construction industry.

Findings from the questionnaire survey revealed that difficulties in recruiting, poor decision making due to not having the right skilled people, lack of quality relevance of training received, low employment rate, inflated costs because of sourcing skills’ from abroad, lack of creative skilled engineers in SA due to increased use of overseas engineer, skills’ deficiency, poor quality delivery, lack of innovative technology changes within the industry, poor performance in the construction industry, emigration and damage to the SA economy as the effects of the engineering skills’ shortages to the construction industry in Gauteng, South Africa. Hence the research objective was achieved from both the literature review and from the structured questionnaire.

9.4 RESEARCH OBJECTIVE 3

The last objective of the current study was to establish measures that can be taken to minimize engineering skills’ shortages in Gauteng, South Africa.
Literature reviewed revealed the following, among others as the major measures that can be taken to minimise engineering skills’ shortages in the construction industry: higher participation in science, technology, engineering and mathematics subjects at secondary level, employers to collaborate with educators to identify the skills’ needed to map career pathways from entry level, government to partner with business and industry, professional engineering institutions to play active role in addressing the performance of STEM subjects, educating young people at an early age about careers, government to upgrade teachers to improve career guidance and invest in higher and further education, support to increase internship mentor relationship with universities, and developing formal in-house and on the job training programs for the graduates.

From the survey results obtained from respondents it was observed that the measures that can be taken to minimise the engineering skills’ shortages in the construction industry are higher participation in science, technology, engineering and mathematics subjects at secondary level; offering career exhibitions to secondary schools; providing opportunities for on-the-job training; improved working conditions; industry professionals to share their knowledge; companies to focus on enhancing existing skills in their businesses; introducing training programs; use of experienced engineers that retired for mentoring programmes; higher remuneration scales for engineering professionals; employers to collaborate with educators to identify the skills needed to map career pathways from entry level to middle skills jobs and beyond; companies to provide additional training and development to existing staff; and positive and good impressions of the industry were amongst the measures to follow to minimise the engineering skills’ shortages according to the results obtained from the questionnaire survey.

9.5 GENERAL RESEARCH CONCLUSION

The main objectives of the study were to identify the causes of the engineering skills’ shortages the effect of the engineering skills’ shortages on the construction industry as well as to determine measures to be taken to minimise the engineering skills’ shortages in the Gauteng Province construction industry of South Africa. The findings and results of the literature study show that the objectives of the research study were achieved. Literature reviewed showed that there are a number of causes of the engineering skills’ shortages in the construction industry in Gauteng, South Africa. The causes identified from the literature were
similar to those identified in the current study. Furthermore, the literature review showed that the engineering skills’ shortages are ranked at the top of the national scarce skills list.

Primary data was obtained through a questionnaire which was sent out to the construction professionals. A total of 200 questionnaires were sent out and 153 were returned, representing a 76.50 per cent response rate. It was indicated by the findings that retirement of experienced engineers; the low pass rate in science, technology, engineering and mathematics subjects; poor career guidance in subjects’ choices; lack of experiential training opportunities; and lack of mentors for new graduates were the major causes of the engineering skills’ shortages in Gauteng Province. The percentage of highly skilled and skilled workers that the country is losing is going to affect the South Africa’s participation in the competitive global field, the low pass rate in science, technology, engineering and mathematics subjects; poor career guidance in subjects choices; lack of mentors for new graduates; and the emigration of experienced engineers are issues that need urgent solutions.

The results from the current study supported the work done by various academics and scholars who conducted their studies on the same research topic.

9.6 RECOMMENDATIONS

There is clearly a substantial demand for engineers in the South African economy. More engineers are needed. We need to ensure that there is a strong flow of talented men and women to meet the demands of our economy, and that means taking action that will deliver. In order to eliminate or minimise the engineering skills’ shortages we are faced with, the following are suggested:

- strongly focusing on maths and science in school;
- offering more experiential training opportunities;
- inspiring young people and helping them to understand and be able to make precise decisions in subject choices;
- inspiring children to consider a career in engineering;
- providing opportunities for on-the-job training;
- offering career exhibitions to secondary schools; and
industry professional sharing their knowledge.

9.7 AREAS FOR FUTURE STUDIES

The study further recommends the following as areas of possible research:

- A study should be conducted on science, technology, engineering and mathematics (STEM) skills.
- A study should be conducted on evaluating in-demand skills’ sets for engineering industry companies.
- A study should be conducted to examine the effectiveness of the engineers in our economy.
- A study should be conducted to evaluate the risks of not having enough competent engineers in our country.
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Vanesh Maharaj, partner with Development Engineering and Consultants (DEC) (Hunt turns offshore for senior-professionals to fill SA’s skills’ gap Sunday Independent 01.07.2007).


APPENDIX 1

University of Johannesburg

Department of Construction Management and Quantity Surveying

Doornfontein, 2028

2016.

Dear Sir/Madam;

LETTER OF INVITATION FOR RESEARCH SURVEY

The Department of Construction Management and Quantity Surveying at the University of Johannesburg is undertaking a research project to assess the “FACTORS RESPONSIBLE FOR THE ENGINEERING SKILLS' SHORTAGES IN SOUTH AFRICAN CONSTRUCTION INDUSTRY”.

To this end, we kindly request that you complete the following short questionnaire. It should take no longer than 20 minutes of your time. Your response is of the utmost importance to us.

To protect your anonymity, please do not enter your name or contact details on the questionnaire.

A summary of the results of this research will be available at the Department of Construction Management and Quantity Surveying.

Should you wish to know the findings of the research, you are welcome to contact Prudence Maake telephonically at: +27723195393/ or at:maakeprudence@yahoo.co.uk or Prof Aigbavboa C.O. at: +2711-559-6398 or at:aigclinton@gmail.com. The faculty will gladly send you a summary of the results.
APPENDIX 2

QUESTIONNAIRE ON FACTORS RESPONSIBLE FOR ENGINEERING SKILLS’ SHORTAGES IN THE SOUTH AFRICAN CONSTRUCTION INDUSTRY

INSTRUCTIONS:

PLEASE ANSWER THE FOLLOWING QUESTIONS BY CROSSING (X) ON THE RELEVANT BLOCK OR WRITTING DOWN YOUR ANSWER IN THE SPACE PROVIDED.

EXAMPLE of how to complete this questionnaire:

Your gender? If you are female:

<table>
<thead>
<tr>
<th>Male</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>2</td>
</tr>
</tbody>
</table>

SECTION A - BACKGROUND INFORMATION

This section of the questionnaire refers to background or biographical information. Although we are aware of the sensitivity of the questions in this section, the information will allow us to compare groups of respondents. Once again, we assure you that your response will remain anonymous. Your cooperation is appreciated.

1. Gender

<table>
<thead>
<tr>
<th>Male</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>2</td>
</tr>
</tbody>
</table>

2. What is your age group?

<table>
<thead>
<tr>
<th>21 years – 25 years</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>26 years – 30 years</td>
<td>2</td>
</tr>
</tbody>
</table>
3. Ethnicity

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>African</td>
<td>1</td>
</tr>
<tr>
<td>White</td>
<td>2</td>
</tr>
<tr>
<td>Coloured</td>
<td>3</td>
</tr>
<tr>
<td>Indian or Asian</td>
<td>4</td>
</tr>
</tbody>
</table>

4. How many years of experience do you have in the construction industry?

<table>
<thead>
<tr>
<th>Experience</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 – 9 years</td>
<td>1</td>
</tr>
<tr>
<td>9 - 14 years</td>
<td>2</td>
</tr>
<tr>
<td>14 - 19 years</td>
<td>3</td>
</tr>
<tr>
<td>19 - 24 years</td>
<td>4</td>
</tr>
<tr>
<td>More than 24 years</td>
<td>5</td>
</tr>
</tbody>
</table>

5. State your highest educational qualification?

<table>
<thead>
<tr>
<th>Qualification</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 11 or lower ( Std 9 or lower)</td>
<td>1</td>
</tr>
<tr>
<td>Grade 12 ( Matric, Std 10)</td>
<td>2</td>
</tr>
<tr>
<td>Post-matric diploma or certificate</td>
<td>3</td>
</tr>
<tr>
<td>Baccalaureate degree(s)</td>
<td>4</td>
</tr>
<tr>
<td>Postgraduate degree(s)</td>
<td>5</td>
</tr>
</tbody>
</table>
6. State the type of organisation that you are currently working for.

<table>
<thead>
<tr>
<th>Organisation Type</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client</td>
<td>1</td>
</tr>
<tr>
<td>Private corporation client (e.g. Banks)</td>
<td>2</td>
</tr>
<tr>
<td>Private sector consultant</td>
<td>3</td>
</tr>
<tr>
<td>Private sector contractor</td>
<td>4</td>
</tr>
<tr>
<td>Public sector (Government)</td>
<td>5</td>
</tr>
</tbody>
</table>

7. What is your level of employment?

<table>
<thead>
<tr>
<th>Level</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Junior</td>
<td>1</td>
</tr>
<tr>
<td>Intermediate</td>
<td>2</td>
</tr>
<tr>
<td>Senior</td>
<td>3</td>
</tr>
<tr>
<td>Manager</td>
<td>4</td>
</tr>
</tbody>
</table>

8. State the number of construction projects in which you are currently involved.

<table>
<thead>
<tr>
<th>Projects Count</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>1</td>
</tr>
<tr>
<td>1 – 2 projects</td>
<td>2</td>
</tr>
<tr>
<td>3 – 4 projects</td>
<td>3</td>
</tr>
<tr>
<td>5 – 6 projects</td>
<td>4</td>
</tr>
<tr>
<td>7 – 8 projects</td>
<td>5</td>
</tr>
<tr>
<td>More than 8 projects</td>
<td>6</td>
</tr>
</tbody>
</table>

9. What is your job title?

<table>
<thead>
<tr>
<th>Job Title</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architect</td>
<td>1</td>
</tr>
<tr>
<td>Quantity- surveyor</td>
<td>2</td>
</tr>
<tr>
<td>Structural engineer</td>
<td>3</td>
</tr>
<tr>
<td>Electrical engineer</td>
<td>4</td>
</tr>
<tr>
<td>Mechanical engineer</td>
<td>5</td>
</tr>
</tbody>
</table>
SECTION B: CAUSES OF THE ENGINEERING SKILLS’ SHORTAGE IN THE SOUTH AFRICAN CONSTRUCTION INDUSTRY

This section of the questionnaire explores the cause of engineering skills’ shortage in the South African construction industry.

Please indicate your answers using the following 5-point scale where:

1 = strongly disagree
2 = disagree
3 = neutral
4 = agree
5 = strongly agree

10. To what extent do you agree that the following are causes of engineering skills’ shortages in the South African construction industry?

<table>
<thead>
<tr>
<th>CAUSES OF THE ENGINEERING SKILLS’ SHORTAGES</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Poor career guidance in subject choices</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2. Retirement of experienced engineers</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. Negative perception of the industry</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>4. Low pass rate in STEM subjects (Science, technology, engineering and mathematics)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5. Low remuneration for engineering professionals</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Lack of experiential training opportunities</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>7.</td>
<td>Number of graduate drop-outs</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>8.</td>
<td>Political instability</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>9.</td>
<td>Lack of government support for tertiary education</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>10.</td>
<td>Immigration of experienced engineers</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>11.</td>
<td>Lack of mentors for new graduates</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>12.</td>
<td>Poor working conditions</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>13.</td>
<td>Growth of new industries with few ready skilled engineers</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>14.</td>
<td>Relocation of new industries into different regions with a different skills’ base</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>15.</td>
<td>Cyclical economy shifts</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>16.</td>
<td>Rising crime</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>17.</td>
<td>Lack of industry-specific qualifications and certifications in terms of professionals</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>18.</td>
<td>Affirmative action</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>
SECTION C: EFFECTS OF ENGINEERING SKILLS’ SHORTAGE ON THE SOUTH AFRICAN CONSTRUCTION INDUSTRY

This section of the questionnaire explores the impact of engineering skills’ shortage on the South African construction industry. Indicate the level of impact the following have to the South African construction industry.

11. To what extent do you agree that the following are effects of engineering skills’ shortages on the South Africa construction industry?

<table>
<thead>
<tr>
<th>EFFECTS OF ENGINEERING SKILLS’ SHORTAGES</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Skills’ deficiency</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2. Lack of innovative technology changes within the industry</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. Lack of quality relevance of training received</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>4. Emigration</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5. Difficulties in recruiting</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>6. Poor working environments and conditions</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>7. Low employment rate</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>8. Poor performance in the construction industry</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>9. Inflated costs because of sourcing skills’ from abroad</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>10. Construction industry unable to grow and expand</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>11. Poor quality of workmanship</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>12. Higher project costs</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>13. Damage to the SA economy</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>14. Poor quality delivery</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>15. Poor decision making due to not having the right skilled people</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>16. South Africa becoming a less attractive place to invest in</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>17. Lack of creative skilled engineers in SA due to increased use of overseas engineers</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
SECTION D: MEASURES OF MINIMISING ENGINEERING SKILLS’ SHORTAGES IN THE CONSTRUCTION INDUSTRY

This section of the questionnaire explores methods to minimise the engineering skills’ shortage in the construction industry.

12. To what extent do you agree that the following measures can be taken to minimise engineering skills’ shortage in the construction industry

<table>
<thead>
<tr>
<th>MEASURES TO REDUCE CURRENT ENGINEERING SKILLS’ SHORTAGE</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Introducing training programs</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2. Industry professionals to share their knowledge</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. Higher market related salaries</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>4. Private sectors to invest in secondary schools</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5. Higher participation in science, technology engineering and mathematics subjects at secondary level</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>6. Government to subsidise full tertiary education</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>7. Offering career exhibitions to secondary schools</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>8. Companies to provide additional training and development to existing staff</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
9. Companies to focus on enhancing existing skills’ in their businesses

10. Using retired experienced engineers for mentoring programs

11. Promoting a positive and good impression of the industry

12. Improving working conditions

13. Higher remuneration scales for engineering professionals

14. Providing opportunities for on the job training

15. Employers to collaborate with educators to identify the skills’ needed to map career pathways from entry level to middle skills’ jobs and beyond

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Thank you for your co-operation in completing this questionnaire.