UNIVERSITY OF KWAZULU-NATAL

Engineering Students and their Prospective Employers – Expectations and Reality

By

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DECLARATION

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  "Therefore glory be unto Him, in whose Hands is the dominion of all things, and unto Him is our return" – Quran (36:83).

ABSTRACT

Since the dawn of democracy in South Africa in 1994, numerous changes have occurred at tertiary institutions to enable greater access for people of all backgrounds and increased graduate throughput to fulfil the needs of the labour market for engineers. Widespread changes in the size and composition of successive undergraduate engineering cohorts have occurred. Simultaneously, the needs of industry have undergone significant changes due to the information age, globalisation and the rapid increase in technological advances and access to technology. This study attempted to assess the alignment between the expectations of students who have graduated in engineering, the expectations of engineering employers and reality. A mixed methodology was developed. The study firstly surveyed engineering graduates at the University of KwaZulu-Natal (UKZN) using a questionnaire developed for quantitative analysis. Convenience sampling and a positivist approach were used. Graduates' needs, study approaches, employment and workplace expectations were determined, analysed and interpreted through the lens of three frameworks, namely Biggs' study motives and strategies, Bloom's taxonomy and Boundaryless and Protean careers. Secondly, the study surveyed all engineering discipline academic leaders at UKZN by qualitative, semi-structured interview within an interpretivist paradigm and using deductive thematic semantic analysis. Academic leaders were used as a proxy for obtaining industry opinion and expectations and questioned on a number of themes including graduate and employer expectations, positive or negative trends, graduate training programmes, further training and postgraduate study, exit-level outcomes (ELOs) and graduate attributes, the reality of mis-alignment and what UKZN can do to limit it. Responses were collated and compared quantitatively and qualitatively where appropriate. A number of issues and mis-alignments was identified together with causes of mis-alignment. Mis-alignment was identified in salary, growth and guidance expectations, confidence, software and niche proficiencies and innovation expectations. Key causes included language barriers, lack of engineering hobbyist backgrounds, workload and study strategies, assessment changes and personal responsibility. Findings were discussed within the three theoretical frameworks mentioned above and summarised in light of the objectives of this study. Recommendations for UKZN to play a role in mitigating many of the issues and mis-alignment were provided, along with recommendations for any possible future research in this area.

TABLE OF CONTENTS

LIST OF TABLES

GLOSSARY OF TERMS AND ABBREVIATIONS

Terms

Study Approaches	Combination of study motives and study strategies
Study Motives	Motivations for learning and pursuing a degree
Study Strategies	Strategies adopted when learning subject matter

Abbreviations

ECSA	Engineering Council of South Africa
EIT	Engineer-in-training
ELO	Exit-level Outcome
IAB	Industrial Advisory Board
Pr.Eng.	Professional Engineer (Registration)
QPA	Quality Promotions and Assurance
SPQ	Study Process Questionnaire
UKZN	University of KwaZulu-Natal

CHAPTER 1: INTRODUCTION TO THE RESEARCH

1.1 Introduction

This chapter contains a description of the background, motivation, focus and problem statement of this study. The aim and objectives, research questions and significance of the study are provided, together with the research methodology utilized and location of the study. Lastly, limitations of the study are outlined, together with a description of the structure of this dissertation.

1.2 Study Background

Poor scholarly habits, a high drop-out rate and a high failure rate in certain core modules have resulted in sustained low student performance in many of the University of KwaZulu-Natal's (UKZN) Engineering Programmes. The increasing number of students repeating modules often require five years or more to complete the four- year BSc.Eng. degree. The average time for an engineering student to complete a four-year programme is now approximately 5.5 years with an average throughput rate of 60% of engineering graduates, according to throughput surveys done by the Engineering Council of South Africa (ECSA) (Fischer, 2011; Pocock, 2012).

It has become increasingly common that academic staff, support staff and tutors offer much criticism and complaint regarding students' lack of deep learning and effective learning strategies and strong presence of surface motives and strategies which ultimately limit student achievement and performance in the workplace (Pocock, 2012).

A study by Naidoo and Osman (2015) indicated that local companies in Durban, South Africa, have also expressed deep concern regarding graduate readiness for the workplace, graduate awareness and sense of responsibility, graduate confidence, independent learning ability, the ability of graduates to apply their knowledge. Poor levels of graduate initiative and engagement were also reported.

The factors often assumed to contribute to the above concerns include the changing curriculum and teaching methodology at the high (secondary) school level, social factors, economic factors and non-scholarly responsibilities of students (Osman, 2016; Carberry and Baker, 2017). These assumptions, however, are often not substantiated by quantitative or statistical evidence, but based rather on academic staff's personal feelings informed by their interaction and qualitative assessment of their students. A more scientific approach is thus required to investigate the changing attitudes, perceptions and backgrounds of students and this has formed the broad aim of this research. This study attempted to provide substantive evidence by conducting quantitative surveys of engineering graduates at UKZN and formally interviewing academic leaders to ascertain the opinions of industry.

Informal teaching and learning studies have been conducted at UKZN to provide qualitative insight into student and employer perceptions. A notable study was presented by Naidoo and Osman (2015) which issued qualitative questionnaires to students and conducted informal interviews with various industry employers including Ethekwini Water Services, Sasol, Mintek and Sappi. While the study was limited in scope, its main revelation was the need to teach students better techniques of sourcing quality engineering data and information. A subsequent study by Osman (2016) was conducted in which 212 undergraduate chemical- engineering students from four cohorts were surveyed to assess students' socio-economic background, their motives and approach to learning and identify any links between them. Important findings at the time of the study were that over 50% of students received financial aid through bursaries, scholarships and student loans, 29.2% ran their own household while studying and 32% of students spent two to three hours a day travelling. Fewer than half of respondents attended all their lectures.

Mis-alignments between new graduate expectations, employer expectations and reality have various potentially negative implications for corporations and the economy in general. These include misguided delegation of duties, workplace tension between new recruits and managers, workplace dissatisfaction among graduates and managers, decline in new recruit interest and productivity, high corporate investments in unproductive operations such as employee training with no guarantee of a return and ultimately the decline in innovation and competitiveness of organizations (Watson, 2009; Tejedor, Segalas and Rosas, 2017; Onar, Ustundag, Kadaifci and Oztaysi, 2018; Almeida, Fernando, Hannif and Dharmage, 2015; Bjorklund and Colbeck, 2001).

Employers of engineers have sought to mitigate any shortcomings of new graduates in their employ by facilitating mentorships and engineer-in-training (EIT) programmes to develop skills that are often specific to the tasks required by the firm. Programmes are often time-consuming and costly to the company and a valuable return on investment in terms of a developed quality employee is not always guaranteed (Tejedor et al., 2018).

This study thus focusses on assessing the alignment of the expectations of new engineering graduates regarding the workplace and that of employers' expectations regarding newly-employed engineering graduates. An assessment of this alignment may contribute to updating curricula and improving teaching and learning in order to better align graduate perceptions to what employers require of them in the workplace. Making this assessment required a thorough analysis of graduates' perceptions. Research and appropriate methodology for this was found in the area of Teaching and Learning research.

Teaching and Learning studies have been pursued for a long time by various researchers. Biggs (1987) developed a novel Study Process Questionnaire (SPQ) containing 42 questions which categorize students' motives and strategies for study into Surface, Deep and Achieving. Motives such as gainful employment, the need to simply pass assessments, obtain a degree and general short-term planning were categorized as Surface motives. Associated with Surface motives, Surface strategies for learning included rote learning, lack of questioning of educators and sticking only to material presented by lecturers. Deep motives were defined as inherent motives to gain an excellent and deep understanding of the pursued career with an intention to add value to the career. Deep strategies include a high degree of questioning of educators, a good pursuit of study material outside of what educators stipulate and strong independent learning. Motives associated with seeking a degree for the prestige of the degree and doing well for the pride of obtaining good grades were considered to be achieving motives. Achieving strategies included excessive studying of past papers, student competitiveness and opposition to group effort and focus mainly on material recommended by educators (Biggs, Kember and Leung, 2001; Hua, Williams and Hoi, 2003).

Numerous developments of the above-mentioned questionnaire have been made with varying success in Australia, Hong Kong and Singapore (Biggs, 1991; Biggs, 1992; Hua et al., 2003). While the SPQ developed by Biggs (1987) and iterated by successive researchers (Hua et al., 2003; Fox, McManus and Winder, 2001; Zeegers, 2010; Biggs et al., 2001) aimed to determine and categorize students' motives and strategies, the study did not attempt to establish any reasons for the prevailing motives and strategies of students. Two studies aiming to combine the SPQ with circumstantial reasons were that of Lizzio, Wilson and Simons (2002) and

Athiyaman (1997); these works formed a detailed framework by which to assess the attitudes, motives, approaches and expectations of new graduates.

Assessment of industry expectations was found to be a far less researched field, though gaining interest in recent years. A review of research regarding industry expectations over the past five years has been conducted in this study. Previous studies include qualitative, quantitative and mixed-methods research. Methodologies and conclusions of previous work were investigated.

This study sought to interview key personnel to get a qualitative insight into employer expectations. Special focus was directed towards industries that have an enduring relationship with the university, provide input at Industrial Advisory Board (IAB) meetings and liaise with discipline academic leaders at the School of Engineering at UKZN.

1.3 Motivation for Study

It is useful at an academic level and university leadership level to constantly gain insights and explore ways of positively transforming the scope and delivery of engineering education to align better with current industry needs. Key insights can be used to identify weaknesses in course delivery and gaps in subject matter in order to address them early so that student quality increases over the course of their degree, to ultimately produce quality, employable graduates with contemporary relevant knowledge in high demand. Identifying and addressing mis-alignments between new graduate expectations, employer expectations and reality can mitigate or prevent various pitfalls in the corporate world wherever engineers are employed. This includes mis-hiring of recruits possessing qualifications that are not well suited to the intended role, mis-delegation of duties that are unsuited to new recruits' strengths, high training costs, employee dissatisfaction and underperformance.

1.4 Focus of the Study

The study focussed on surveying two populations, namely engineering students who recently graduated and discipline academic leaders at UKZN. The study focused on 2019 engineering graduates from the disciplines of Agricultural, Civil, Chemical, Electrical, Electronic, Computer and Mechanical engineering at UKZN. Graduate surveys were conducted during graduation ceremonies (25 April 2019) and academic leaders in charge of each of the above disciplines of engineering were interviewed, by personal appointment, at UKZN offices.

A mixed methodology approach was adopted. The graduate survey consisted of three sections. Section A and B entailed a positivist approach while Section C entailed mixed methods incorporating positivist and interpretivist approaches, since written responses to open-ended questions were required in this section. However, with limited variance in the types of responses provided, categorising of responses was possible, thus enabling statistical analysis. Semi-structured academic-leader interviews entailed an interpretivist approach and results were analysed thematically.

While the above focus represents a snapshot of the current situation, inquiries were made regarding observed trends during interviews. A triangulated approach was also attempted by considering and comparing the results of the 2019 UKZN Quality Promotion and Assurance (QPA) Graduate Opinion Survey held at each UKZN graduation ceremony (QPA, 2019), thereby broadening the scope of the discussion. In this manner a mixed-methods approach was achieved.

1.5 Problem Statement

While engineering graduates obtain a good understanding of the fundamentals of engineering at university, the extent and adequacy to which universities prepare them for the engineering workplace is debatable. Many industries have resorted to putting their newly-employed engineering graduates through two-year EIT programmes and other short courses which are often expensive and yet still do not guarantee a successful employee thereafter. In regular meetings with UKZN colleagues at the engineering discipline and school level from 2014 to 2018, numerous concerns often emerged regarding the extent of deep thinking that engineering students actually achieve, with a lack of deep thinking linked to lack of innovation and creativity, the true hallmarks of capable engineers (ECSA, 2019; Mulder, 2017; Osman and Naidoo, 2015; Pocock, 2012).

This research intended to investigate the expectations of engineering graduates and employers of engineering graduates, assess the current reality and establish what the UKZN School of Engineering may do to bridge the gaps in knowledge and perception, enabling more successful transitions of its graduates between university and the workplace, ensuring greater success of graduate training programmes, better productivity and ultimate success in the innovation and competitiveness of enterprises that employ engineers.

1.6 Aim and Research Objectives

The aim of the research is to assess the alignment (or mis-alignment) between expectations of new engineering graduates at UKZN, the expectations and deeply sought-after values of engineering employers and reality. The research objectives are listed as follows:

- To determine the employment and daily-work expectations of newly-graduated UKZN engineering students;
- To ascertain the expectations of engineering employers in KwaZulu-Natal concerning newly-employed graduates;
- To identify any positive and negative trends that employers have observed over time with new graduate intakes;
- To establish ways in which UKZN could assist in bridging the gap between graduate and employer expectations to ensure enhanced productivity.

1.7 Research Questions

- What are the employment and daily-work expectations of newly-graduated UKZN engineering students?
- What expectations and hopes do current engineering employers have for today’s engineering graduates?
- Are there any changes or trends, positive or negative, that have occurred in engineering graduates as observed by employers?
- How can UKZN assist in bridging the gap between graduate and employer expectations to ensure enhanced productivity?

1.8 Significance of the Study

The study is very important in establishing the groundwork to reform engineering education to meet the needs and contexts of contemporary students accepted for study at UKZN. Numerous changes have occurred in the climate of South African tertiary education. Along with the rest of the world, advances in telecommunications have led to an information explosion with many more individuals gaining access to information through the internet – information previously denied to them by more conventional means. Such advances have changed the culture and way students learn and the learning methods to which they are more receptive. This has potentially affected graduate quality and expectations for employment and, in turn, new employee performance in the workplace (Mtshali, 2019; ECSA, 2019; Tshibangu, 2015).

Studies are thus essential to determine the extent of these changes and their impacts, how they affect employment and employee performance and whether or not current methods are still adequate to develop graduates that meet contemporary needs of industry. To accomplish this, it is imperative that the perspectives of graduates, heads of schools and industry partners be ascertained in order to achieve better alignment between teaching methods, successful graduate employability and performance in the workplace.

1.9 Research Methodology

The carefully considered design of the research methodology entailed surveying two types of respondents, namely engineering graduates and engineering discipline academic leaders. The primary rationale was to achieve the highest possible response rate, given the time constraints of the research, for results to be regarded as credible.

A mixed methodology approach was thus followed. A positivist approach was taken when surveying graduates, as 50 graduates participated in the survey. A questionnaire containing mainly multiple-choice questions and solution ranges was developed, with a limited section of open-ended questions requiring written responses necessitating a mixed-methods approach; the variety of written responses was limited so that responses could be grouped and analysed statistically.

Convenience sampling was practised as graduates were surveyed while attending their graduation ceremony together, in order to meet the first objective of this research. At the venue itself, stratified probabilistic sampling was conducted, with the aim of surveying at least 20 graduates from each engineering discipline. All data was ultimately analysed statistically using MS Excel. With academic leaders however, an entirely interpretivist approach was followed. Semi-structured one-on-one interviews were held with each academic leader of the various engineering disciplines at UKZN. Interview data were recorded and transcribed using Amberscript software and MS Word and analysed thematically in a generally deductive, semantic manner. All insights were collated and compared to standard survey results from the UKZN QPA Department’s Graduate Opinion Survey which is held annually during graduation ceremonies. Details of all aspects of the research methodology are explained in Chapter 3.

1.10 Limitations of the Study

The surveying of respondents was limited to UKZN engineering students who were graduating in 2019 and UKZN staff. While the survey of engineering graduates was accomplished through issuing questionnaires, major employers could not be surveyed due to time and resource constraints. However, employer views and opinions were indirectly obtained by conducting interviews with academic leaders and senior accredited engineering staff at UKZN's School of Engineering. Such personnel are in constant contact with major industrial partners either via personal contact or via IAB meetings which advises each engineering discipline on curriculum updates and teaching methodology. Thus, interviewing these personnel provided a credible way of ascertaining employer expectations and perceptions of engineering graduates.

Although the survey was limited to UKZN, all engineering schools in South Africa are accredited by ECSA and are thus similar in curricula. The employers of UKZN graduates also employ engineering graduates from other institutions in South Africa and findings of this study may thus be generalisable throughout the country, although it would be prudent not to make that assumption but rather conduct similar studies in other institutions as well.

1.11 Structure of the Dissertation

Chapter 1 introduced the topic of this research. Chapter 2 begins with a review of the current situation of engineering employment, the UKZN School of Engineering and ECSA. Three education and assessment frameworks were useful for this study and they are explained herein. Chapter 2 ends with a review of contemporary engineering-education issues in order to establish the relevance of this study. Chapter 3 presents the research methodology used in this study, including the research paradigm, research design and survey instrument design. Sampling approaches and data analysis are also explained, together with an assessment of the validity of the results. Chapter 4 presents the results. Graduate responses were largely quantitative and are presented in tabulated form, while interview responses were presented in the form of a summary and quotations. In Chapter 5, results are assessed holistically and compared to determine any alignment or mis-alignment between graduate expectations, employer expectations and the prevailing reality. Chapter 6 presents key findings in light of the study objectives and provides recommendations for future research in this area.

1.13 Conclusion

This chapter introduced the background of this research, including the motivation, focus, aims and objectives, research questions and problem statement of this study. The location and significance of the study have been described, as well as a brief description of the research methodology applied in this work. Limitations of this study have also been declared. Lastly, the structure of the dissertation was presented. The next chapter provides a deeper insight into the background of this research, as well as a review of previous relevant studies and frameworks associated with this research.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter contains a review of contemporary and past studies pertaining to the topic of this study. The chapter begins with a review of the current situation of new graduate employment in engineering in South Africa as well as issues of graduate throughput in the field of engineering. UKZN's School of Engineering is then introduced as it forms the basis of the context of this study. Perceptions and benchmarking of graduate quality are then introduced, with the key institution being identified as ECSA. Issues pertaining to graduate throughput and benchmarking are highlighted and compared to some other cases internationally. Since the study involved ascertaining graduate expectations, which are driven in part by graduate backgrounds, motives and strategies, frameworks relevant to teaching and learning in engineering education have also been investigated and presented herein. These frameworks include Bloom's taxonomy, Biggs Study Motives and Strategies and Boundaryless and Protean Careers, which form the basis of key discussion points in successive chapters. Lastly, the relevance of this study in relation to all other issues was investigated through a general review of past and contemporary issues in engineering education.

2.2 Review of Current Situation and Previous Research

Engineering ranks as among the most difficult of careers to pursue, requiring candidates to possess strong mathematical, scientific and technical ability. Key attributes to the success of an engineer is an enquiring mind, creativity, innovativeness, self-motivation and an overall drive for excellence (ECSA, 2019).

One of the legacies of Apartheid was the denial of certain race groups from raising a cohort in the fields of science, engineering, medicine and other fields (Badsha, 2016). The advent of democracy allowed access for all race groups to pursue engineering as a career. However, many candidates from previously disadvantaged race groups pursue the career with a dismal lack of social capital of professional elders who have worked through a career in engineering and can provide good practical career advice to current hopefuls (Pronyk, Harpham, Busza, Phetla, Morison, Hargreaves, Kim, Watts, Porter, 2008; Badsha, 2016).

According to numerous sources (Topco, 2017; ECSA, 2014), the engineering profession remains the most sought-after profession in South Africa. Mashigo (2016) lists the top three professions ranked as "Scarce skills" in South Africa to be engineering professions, namely Civil Engineering, followed by Electrical and Mechanical Engineering. Despite this, numerous engineering graduates remain unemployed. Engineering in South Africa ranks 11th in an unemployment survey for the fields with the highest rate of unemployment (Job Vine, 2015), with some fields of engineering having an unemployment rate of 9.2% of graduates, while materials engineering has a 7.7% unemployment rate.

Although candidates may have the technical abilities required of engineers and graduate with an engineering degree at university, many graduates find great difficulty coping, growing and succeeding in an engineering career. Large industries have stepped in by providing two-year EIT programmes for their new graduate employees (Mtshali, 2019; Easa, 2013). These EIT programmes are often specific to the industry in which an engineer works and costly, requiring much investment on the part of companies before they can actually see meaningful returns from their investment in their new engineers. Many engineers go through EIT programmes and display substandard performance. This typically threatens their job security, with engineers finding themselves jobless after the two-year programme (Mulder, 2017).

The engineering profession is plagued with a number of issues at graduate level. In a study of chemical-engineering students, in particular, it was found that poor scholarly habits, a high drop-out rate and a high failure rate in certain core modules have resulted in sustained low student performance in the UKZN Chemical Engineering Programme, with an increasing number of students repeating modules, thereby often requiring five years or more to complete the four year BSc.Eng. (Chemical) degree (Pocock, 2012). The average time for a chemical engineering student to complete a four-year programme is approximately 5.5 years, with an average of 60% throughput rates of engineering graduates according to throughput surveys done by ECSA (Fischer, 2011; Pocock, 2012; Osman, 2016).

2.3 The UKZN School of Engineering and the Engineering Council of South Africa

The School of Engineering at UKZN is led by a "Dean and Head of School" and comprises seven ECSA accredited engineering programmes (known at UKZN as "Disciplines") including

Agricultural, Chemical, Electrical, Electronic, Computer, Civil and Mechanical Engineering. The School also covers Land Surveying, Quantity Surveying and Construction Studies according to demand. The School has an academic staff complement of 64 and graduates, on average, 350 students each year (UKZN, 2013). While there are seven disciplines, there are only four "academic leaders" who lead these disciplines. Chemical and mechanical engineering each have one academic leader. The disciplines of electrical, electronic and computer engineering are grouped into a single cluster led by a single academic leader. Similarly, the disciplines of agricultural and civil engineering are grouped into a cluster and led by a single academic leader. Although surveying and construction studies also form part of the cluster with agricultural and civil engineering they were not included in this study as the focus was only on engineering.

The standard of engineering education at UKZN is monitored, along with that of seven other large universities in South Africa, by ECSA. ECSA is a signatory of the Washington Accord, which is a mutual recognition of education qualifications in the field of education of engineers (ECSA, 2019). ECSA in turn receives periodic review and affirmation of its reputability through its participation in and co-oporation with, the International Engineering Alliance (IEA). Standards are reviewed by the IEA every six years and ECSA in turn reviews the standards of South African institutions every five years by conducting accreditation visits (ECSA, 2019).

Engineering curricula are assessed for their ability to assess and achieve eleven graduate attributes in students, namely: Problem solving; application of scientific and engineering knowledge; engineering design; investigations, experiments and data analysis; engineering methods, skills and tools including information technology; professional and technical communication; sustainability and impact of engineering activity; individual, team and multi-disciplinary working; independent learning ability; engineering professionalism; and engineering management (Mtshali, 2019). Each institution's engineering programme is required to justify how its curriculum and individual modules serve to inculcate and assess the above attributes that graduates ought to graduate with.

Other countries have engineering councils with similar approaches. The framework used by the Engineering Council in Canada, for example, has 12 graduate attributes to assess engineering graduate programmes (Easa, 2013): Knowledge base; Problem analysis; Investigation; Design; Use of engineering tools; Individual and teamwork; Communication skills; Professionalism; Impact on society and environment; Ethics and equity; Economics and project management; Lifelong learning. Easa (2013) identified that success of the assessment process relied on continuous interaction between quality assessors, working groups, frequent meetings between engineering chairs and instructors, programme coordinators and social retreats. Future recommendations for electronic repositories were made to track changes and trends, although assessment is still done manually. Simple assessment methods which also exhibit assessment triangulation (different methods coming together) are encouraged.

Malaysia's Engineering Accreditation Council (EAC), however, had a significantly different approach to assessing engineering education (Said, Chow, Mokhtar, Ramli, Ya and Sabri, 2011). The EAC's stance is that the greatest need for accreditation authorities is due mainly to globalisation of the profession. Engineering is one of the most globalised professions, enabling graduate engineers to easily be employed across borders without the need of further board exams or equivalency tests (ECSA, 2019). The engineering education sector thus has to be well regulated and meet stringent criteria to ensure that an institution is producing competent engineers. The body thus focuses on accreditation rather than more encompassing roles that ECSA or the Canadian Council takes on, such as continuous professional development and promotion of professional engineering registration.

While South Africa, Canada and other engineering councils have 11 or 12 engineering attributes or outcomes centred around student abilities, in Malaysia accreditation is grouped under six topics: Programme Educational Objectives (PEOs) and Programme Outcomes (POs); academic curriculum; students; academic and support staff; facilities; and Quality Management System. The topics are explicit and centred not only on student abilities but also the institution itself (Said et al., 2011; Easa, 2013).

The benefits of Malaysia's accreditation system were assessed through benchmarking and questionnaires (Said et al., 2011). The system was, however, found to be cumbersome and slow in implementation. The EAC adopted an outcomes-based education (OBE) approach and the focus on OBE at the tertiary level made it difficult for academics to conduct research. Institutions also grappled with whether to focus on preparing students for a professional engineering or research career and how to strike a balance. The introduction of an "Engineering Sciences" degree was even proposed.

The issues of monitoring and assessing programme and graduate quality at UKZN and University graduates in South Africa in general are thus not unique. Other countries exhibit similar concerns and investigate different approaches. However, despite ongoing review and assessment, engineering programmes have endured minimal change in terms of curriculum over the years, with fundamental engineering concepts still remaining as relevant as ever (Downs, 2014). Concerted effort has been made to introduce soft skills, presentation skills including slide shows, poster presentations, lab demonstrations and even video material. A study by Downs (2014) found that universities are being pressured to offer more online courses and even degrees to keep up with modern societal expectations of lower-cost education and more education access, including distance learning. Often, not much attention is paid to quality. While the curriculum is up to a standard acceptable and accredited by relevant bodies, the study in a Mid-Western university in the US on three science-technology-engineering-mathematics (STEM) online programmes found that evaluation and assessment consisted mainly of informal feedback from students, student satisfaction surveys and student grades and performance information (Downs, 2014). This lacked structured collection and reporting mechanisms, resulting in vast differences in implementation between online and traditional course delivery, varying data and untrustworthiness of information access and delivery. An effective way to assess whether quality learning has been achieved, is an ongoing pursuit.

With the intensive content of an engineering syllabus, students are often under great pressure to simply go through the content and try to pass assessments, with very little opportunity for deep thinking, deep learning and formulation of career planning and ambitions. Rote learning by students is often prevalent, resulting in dismal pass rates in many engineering modules (Pocock, 2012; Osman, 2016). Moreover, opportunities for industry interaction, vacation work, excursions and industrial experience are minimal, with very few companies offering vacation work; students have no opportunity to successfully pursue fulltime engineering studies while being employed. Despite the constraints however, it is possible to at least change the manner in which content is created. Current methods sustain a surface learning, with rote learning and often a lack of student interest in the content due to the content being perceived as too theoretical. The amount of theory delivered at university and graduates' limited practical thinking is a frustration particularly for small firms who are then tasked with investing in further training programmes to equip their employees with necessary skills (Naidoo and Osman, 2015).

It has become increasingly common that academic staff, support staff and tutors offer much criticism and complaint regarding students' lack of deep learning and effective learning strategies. The strong presence of surface motives and strategies adopted by students ultimately limit their achievement and performance in the workplace. A previous study by Naidoo and Osman (2015) of five industry partners recorded concern regarding graduates' ill-preparedness, including readiness for the workplace, awareness and sense of responsibility, confidence, independent learning ability to apply their knowledge, level of initiative and engagement. The study also uncovered a lack of confidence in many graduates about independently seeking quality information.

2.4 Tertiary Education Assessment Studies and Frameworks

The factors often assumed to contribute to the above concerns include the changing curriculum and teaching methodology at the high school level, social factors, economic factors and non-scholarly responsibilities of students. These assumptions, however, were not substantiated by quantitative or statistical evidence, but rather by anecdotal evidence from academic staff interaction with and assessment of their students and observations by human resource personnel. A more scientific approach is thus required to investigate the changing attitudes, perceptions and backgrounds of students.

In an attempt to address this issue, this study will use three theoretical frameworks, namely Bloom's taxonomy, Biggs study motives and strategies and concepts of Boundaryless and Protean careers.

2.4.1 Bloom's Taxonomy

In order to analyse the pedagogy of engineering education, it is important that concepts of learning ability and educational goals be clearly defined. A thorough classification was conducted by Bloom, Engelhart, Furst, Hill and Krathwohl (1956), which came to be known as "Bloom's taxonomy". Educational goals are classified into six categories, often displayed as a pyramid. The six categories are listed from the simplest to the most complex as follows (Adams, 2015):

a) Knowledge/Remembering: concerns the most basic ability of remembering facts, even if one does not understand them. These can be categorised into knowledge of specific concepts, terminology, conventions, trends, sequences, theories, principles and generalisations.
b) Comprehension/Understanding: being able to understand concepts, draw comparisons, make descriptions, describe ideas and interpret.

c) Application: being able to apply prior knowledge to new situations and case studies and solve problems.
d) Analysis: being able to break down concepts and information into component parts, finding relationships, motives, inferences and looking at evidence.
e) Synthesis: a high educational goal, to be able to take established knowledge and findings and build new patterns, ideas, concepts or structures.
f) Evaluation: being able to present, judge and defend opinions. Being able to judge work based on quality using various criteria, examining the validity of ideas based on evidence.

While Bloom's taxonomy was developed in 1956 by Bloom et al. (1956), it has been adapted and modified in a variety of ways to categorise education goals pertaining to the study of emotion, teaching practice and cognitive ability (Simpson, 1966; Anderson, Krathwohl, Airasian, Cruikshank, Mayer, Pintrich, Raths and Wittrock, 2001; Fadul, 2009; Clark, 2015). The classification has also received criticism for its limitations as it does not include key aspects such as student attitude, motives and strategies. The traditional education system that accepts Bloom's taxonomy is also criticised by Paolo Freire (Provenso, 2006) for being in essence a type of banking system where students are seen as empty bank accounts, waiting to be filled with education, a system that is regarded as perpetuating oppression. Nevertheless, the concepts are still relevant to at least categorise and assess the delivery of education in engineering schools.

2.4.2 Biggs Study Motives and Strategies

While Bloom's taxonomy is sufficient in categorising the various goals and tiers of education, it does not provide any indication of how the tiers of education are affected by the actual pedagogy, the relationship between students and teachers and the personal motives of students.

Numerous studies have been conducted aiming to determine and analyse respondents' motives and strategies in pursuing their chosen degree. Biggs (1987) developed a novel Study Process Questionnaire (SPQ) containing 42 questions to categorize respondents' motives and strategies, with the assumption that the inherent motives of students affect their study strategies and the tiered level of education they achieve according to the Bloom's taxonomy. Study motives and strategies were categorized by Biggs into that of "Surface", "Deep" and "Achieving".

Motives such as gainful employment, the need to obtain a degree, or general short-term planning that exhibits a lack in foresight, were categorized as "surface motives". Associated with surface motives, “surface strategies” for learning included rote learning, lack of questioning of educators and sticking only to material presented by lecturers. Motives associated with seeking a degree for the prestige of the degree and doing well for the pride of obtaining good grades were considered to be “achieving motives”. “Achieving strategies” included excessive studying of past papers, student competitiveness and opposition to group effort and focus mainly on material recommended by educators. “Deep motives” were defined as inherent motives to gain an excellent and deep understanding of the pursued career with an intention to add great value to the career. “Deep strategies” include a high degree of questioning of educators, a good pursuit of study material outside of what educators stipulate and strong independent learning (Biggs, 1992). Depth in motive and strategy is preferred in order to realize creativity in new and developing engineers (Cropley, 2016).

Numerous developments of Biggs’ questionnaire have been made with varying success in Australia, Hong Kong and Singapore (Biggs, 1991; Biggs, 1992; Hua et al., 2003). While the SPQ developed by Biggs (1987) and iterated by successive researchers (Hua et al., 2003; Fox et al., 2001; Zeegers, 2010; Biggs et al., 2001), aimed to determine and categorize students’ motives and strategies, the study did not attempt to establish any reasons for the prevailing motives and strategies of students. Three such studies aiming to combine the SPQ with circumstantial reasons were those of Lizzio et al. (2002), Athiyaman (1997) and Osman (2016).

The framework developed by Biggs (1987), however, can assist in determining the current motivations of students in a cohort and across cohorts to establish the extent of surface, achieving, or deep learning that is achieved. In the questionnaire, each respondent is asked a total of 42 questions in an effort to cross examine the respondent on their motives and strategies when pursuing any degree. The questions are also arranged in a structured, staggered manner. For example, questions “1”, “7”, “13”, “19”, “25”, “31” and “37” all ask questions that aim to measure the respondent’s extent of surface motives. Questions “2”, “8”, 14”, “20”, “26”, “31” and “38” aim to measure the extent of deep motives. Questions “3”, “9”, “15”, “21”, “27”, “32” and “39” aim to measure the extent of surface motives. In the same manner the extent of surface strategies is measured by questions “4”, “10”, “16”, “22”, “28”, “33” and “40” and so on for measuring the extent of deep and achieving strategies (Biggs, 1987; Osman, 2016). In order to assess the scores, comparative tables presented in Biggs (1987) were traditionally used. The comparative tables for males and females enrolled in science and engineering are available in Biggs (1987). These tables were used to provide a score ranging from one to ten, where scores of eight to ten indicate strong tendency (labelled using a “+”), five to seven indicate neutral tendency (labelled using a “0”) and one to four indicate weak tendency (labelled as “-”) towards the particular motives and strategies mentioned above. For students found to have no distinctive motives and strategies, motives and strategies were summed up to produce “Approaches”. The four isolatable approaches included “Surface”, “Deep”, “Achieving” and “Deep Achieving” approaches. Where students did not possess a distinctive motive and strategy, their results were to be converted from scores ranging from one to ten, to scores indicating dominance (“+”), neutrality (“0”) and weakness (“-”) of each motive, strategy and approach. By categorizing each motive, strategy and approach as represented by these three indicators, it was possible to establish any dominance, weakness or even exclusivity in respondents’ motives, strategies and approaches.

The framework is not perfect. Previous studies (Osman, 2016) found that Biggs’ (1987) original set of questions was too long and cumbersome. Participants became impatient and eager to finish the questionnaire and often ended up answering flippantly rather than honestly. The categorization process was also too detailed, to the point of not practically being able to categorize most students and ascertain whether motives and strategies were definitively, or at least strongly, resembling either deep, surface or achieving traits. It is also challenging to survey students over an entire degree, since students’ motives and strategies can change based on the type of module they are studying. Some modules are energy intensive and encourage rote learning especially in a pressured environment, while other modules require report writing and practical assessments that encourage deep thinking and deep strategies.

This study utilizes the condensed version of the questionnaire outlined in Biggs (2001), which simplifies the categorization process by eliminating the category of “achieving motives” and “achieving strategies”. The condensed version also does not attempt to isolate and categorize motives and strategies independently, but rather combines them into “Approaches”.

2.4.3 Boundaryless and Protean Careers

Minimal research has been conducted on graduate readiness and employer expectations of engineering students. Respondents of a survey by Naidoo and Osman (2015) indicated that employers maintain confidence in engineering degrees that are accredited by ECSA. However, despite this, Topco (2017) has revealed the unemployment of engineers in South Africa to be a structural issue with relatively few companies prepared to take on new graduates, while there exists a high demand for experienced engineers with five or more years’ experience and preferably registered as professional engineers with ECSA. Expensive EIT programmes and short courses have been normalised in that many employers accept graduate shortcomings as a norm and accept the responsibility of training graduates further (Cropley, 2016; Onar et al., 2017).

Biggs' (1987) study and its many amendments discussed above, have made great strides in establishing links between student motives and strategies at the university level, while studies by Hoeksema, Vliert and Williams (1997) attempted to investigate the effects of learning motives on career success, identifying links between organisational structure and types of thinking.

Further research was pursued by Hall and Chandler (2005) and Heslin (2005), investigating factors contributing to career success. Common factors that contributed to career success were deep and achievement thinking and a factor that encouraged deep thinking was an integrated organisational structure as opposed to a centralised organisational structure. Integrated structures encouraged graduates to think for themselves while highly centralised structures typically managed employees and told them what to do. Objective success measures included remuneration, benefits and promotion. Furthermore, researchers, including Hall and Chandler (2005) and Arthur, Khapova and Wilderom (2005), found that career productivity, inventiveness and innovation, which are less objective measures of success, were also more readily achieved through the encouragement of deep thinking.

Concepts of "Boundaryless careers" and "Protean careers" emerged, with Briscoe and Hall's (2006) definition of a Boundaryless career referring to a ranking of the physical and psychological mobility of a career. Four categories were developed: low physical and low psychological mobility, high physical but low psychological mobility, low physical but high psychological mobility and high psychological and high physical mobility. Bridgstock (2011) found that this conceptual framework can be used to assess the extent to which opportunities are opened to engineering graduates and employees, taking into account their employer's organisational structure, to encourage psychological mobility and career shifts suited to employees and to provide opportunities for those shifts within the organisation.

"Protean careers" focus on employees' motivations beyond objective measures of success and attempt to identify and measure the degree to which an employee is value-driven and self-directed, seeing his/her career as a calling, having self-made goals, seeking to make an impact or influence on society (Briscoe and Hall, 2006; Bridgstock, 2011).

Research concerning the attitudes, expectations and success of newly-employed graduates will be conducted within the theoretical and conceptual frameworks described by the concepts of "Boundaryless" and "Protean careers", with ideals identified as deep thinking, self-motivation, psychological and physical job mobility, self-direction and a drive for value beyond objective success measures such as salaries, benefits and promotions. These ideals are worth pursuing because they ensure the success of EIT programmes and employee retention, producing the innovative solution engineers are intended to achieve.

2.5 Engineering Education – An Ongoing Study

Studies concerning tertiary education in general are numerous and ongoing, including the study of engineering education. Numerous traditional and novel approaches have been investigated as technologies of surveying continue to advance, particularly from paperback and hard-copy data collection methods, to electronic surveys and repositories.

A traditional approach was pursued by Townsend (2005) who surveyed geotechnical engineering graduates and employees using questionnaires and by conducting interviews. The paper concerns the challenges faced particularly in geotechnical engineering education, which is a branch of civil engineering in most universities, including UKZN. The current climate of geotechnical engineering was surveyed, as well as issues of motivation, research and funding support, any role distance education can play and other recommendations. Salary has been identified as a primary motivation for engineering students and they choose not to specialise in geotechnical engineering as it is more difficult but does not command a higher salary. Research funding was also found to be lower so fewer geotechnical engineers pursued PhD research. Rewards for publishing research in this field were also less attractive due to research often being rewarded according to the number of publications rather than the quality and relevance.

Feutz and Zinser (2011) pursued an interview-intensive approach to tracking engineering graduates who were employed in the refrigeration and air-conditioning industry after obtaining a BSc. in Heating, Ventilation and Air Conditioning (HVAC). A qualitative study was conducted in order to gauge any positive perceptions of engineering programmes and ascertain any area for curriculum improvement. Interviews contained open-ended questions. The questions enquired about what the HVAC programme meant to interviewees on a personal level, their perceptions of their own self-readiness for their careers, their opinions on what the essential academic, general and non-academic elements of a relevant HVAC programme should be and any recommendations they would make on how to improve on the programme's relevance and pedagogy. Eighteen graduates were interviewed. Respondents appreciated the non-generality of the programme. Graduate attitudes were gauged not directly, but rather indirectly. Feelings of personal pride and gratitude for being part of the degree were often not explicitly stated but implied in speech. Also, the overall campus experience gave them meaningful friendships and acquaintances. The study identified that internships were an excellent way to facilitate the transition from an inexperienced graduate lacking in confidence to a competent and confident employee. Respondents also revealed that more focus on business should be made in the curriculum. Also, being familiar with the concept of job rotation and learning how to fit each aspect of a company together in a business would have been a helpful skill. Criticism of follow-up online courses was the lack of the social aspect between conventional and online education. Online courses only meant something to people who were currently in a job and doing the associated duties since they could obtain theory from the courses and see it in practice in their workplace.

Drawing from the OBE approach, OBE, Timmerman, Feldon, Maher, Stirckland and Gilmore (2013) investigated a direct method of assessing graduate ability by having graduates write a research proposal which was assessed. Graduate ability to research and provide a literature review, context, hypothesis, experimental design, proposed data selection and analysis was assessed. The intention was to assess students entering a programme and re-assess them as graduates leaving the programme to identify differences and progress. The limitations of the study was that progress was found in some students but not others and the causality of this was not easily identifiable. It was, however, effective in assessing whether students leaving a programme had necessary competency. This study was innovative in that it did not rely on opinion and questionnaires or interviews to assess graduate ability, but rather assessed graduates by giving them a well-rounded task of developing a research proposal.

Kajfez, Mohammadi-Aragh, Brown, Mann, Carrico, Cross, Janeski and Mcnair (2013) investigated electronic portfolios (Eps) as an assessment tool for graduate programmatic assessment which is relevant particularly because of the individualised nature of graduate education. Eps are a digital collection space for students' submissions, providing authentic, reliable evidence in an organised manner to enable the students to reflect on their progress and competency, as well as educators to emphasise key knowledge and skills. It can be used as a customizable tool to assess engineering graduate programmes. While promising in theory, the method is cumbersome as each graduate's portfolio must be thoroughly populated throughout the student's undergraduate career to become useful. This is an old idea based on paper evidence, a method which electronic formats have made marginally easier. However, for students to benefit, the method requires lots of effort and buy-in from students providing submissions and educators analysing and using the evidence in a productive manner. It can encourage reflection and motivation if conducted successfully (Raoufi, Park, Khan, Haapala, Psenka, Jackson, Kremer and Kim, 2019).

More generalised studies have also been conducted. Tretko and Vashkurak (2017) aimed to analyse the effect of globalisation on engineering education, specifically in the field of nano-electronics and materials. The study identified three centres of importance to modern global society, namely technocentrism (focus on technical economic systems), sociocentrism (focus on human capital and social expectations) and ecocentrism (focus on natural resources and ecological capacity), all of which contribute to the sustainable development of society. The study provided a good understanding of the process of learning which was identified as: firstly, determining necessary skills; secondly, establishing interrelation and collation of learning results and demands; thirdly, determining global direction; fourthly, integrating interdisciplinary fields in engineering education; and lastly, monitoring the learning results. Issues concerning technocentrism and sociocentrism were also touched upon by Slaton (2015) whose study explored race and gender equity in particular and highlighted the resultant differing ideologies that may arise, thereby impacting the motive and approach to engineering education. Technocentric approaches, specifically in electrical engineering education, were explored by Maciejewski, Chen, Byrne, Miranda, Mcmeeking, Notaros, Pezeshki, Roy, Leland, Reese, Rosales, Siller, Toftness, Notaros (2017).

While the above research can be described as an inside-out approach beginning with institutional study of graduates, industry and national institutions have also conducted outside-in studies of their own. Drawing from the example of the Military, Howell (2016) looked at the Mission-essential task list methods of job rotation and unit training. The study looked at the army environment and the principles of unit training which can be used for successful rotation of engineers in the workplace to develop competency, where a "mission" is conceptualised and a mission-essential task list is set up to include a collective training plan, leader-development plan, assessment plan and resource allocation. Rotations to the next task or project include assessment of previous tasks and projects. In this manner, competency in all necessary fields of work are achieved.

Another study investigated the Model of Personal and Social Responsibility (MPSR) and was investigated at high (secondary) school level by interviewing educators (Martinez, Alonso, Valenzuela, Marmol and Funes, 2017). The model looked at how sports gave youth social skills and how achievements in sport, whether simple wins as a team or big wins, developed social responsibility in them. Sport was found to teach students how to be responsible for themselves and others. Five levels of responsibility are identified: respect for others' rights and feelings; effort; autonomy; help and concern for others; and transfer of what they have learned to contexts outside the programme. The model was assessed qualitatively using interviews or focus groups. Fourteen questions were developed. The study found that certain sports benefited social and personal responsibility development while others did not. This could be taken into account in the hiring process at workplace level and is seen as contributory to successful teamwork, a skill that all successful engineers need to excel at.

The study by Bielefeldt and Canney (2016) presents an initiative to help science and engineering students get an understanding of how scientific expertise plays a role in science and engineering policy, which is a topic that most students do not grasp in their science and engineering degrees. A programme was set up and surveys were conducted pre, post and one year after the programme to assess whether students viewed their world and career differently. The programme was found to help scientists' and engineers' ability to participate in macro-ethical debate, advance their perception and values of engineering in society and pursue participation in policy processes. The programme runs over ten to twenty days, beginning with a group session of 90 minutes, then days of lectures from guest speakers and ending with students being interactive and discussing their knowledge in a controlled manner through group or individual presentations. Most students start out by assuming a long connection between scientific effort and eventual policy, but this is not necessarily the case in practice. This is the most enlightening fact they learn and is also corroborated by later work (Bernstein, Reifschneider, Bennett and Wetmore, 2017).

Other contemporary issues in engineering education concern gender and race equity in engineering education, integration of programmes, issues concerning when it is valid or invalid to adopt meritocratic approaches in assessment, the impact of the technological revolution, as well as the effects of de-politicisation and re-politicisation of engineering education (Cech and Sherick, 2015; Maciejewski et al., 2017; Slaton, 2015). Research and debates concern student and new graduate attitudes, cases for purely technical perceptions of engineering or cases for inclusion of political awareness, environmental impact awareness and social responsibility attitudes (Bielefeldt and Canney, 2016).

2.6 Studies in Graduate and Employer Expectations

There has been limited research conducted to ascertain employer and graduate expectations to provide insights to university curriculum development. Khoo, Zegward and Adam (2016) used a mixed-methods approach of online questionnaires and focus-group interviews to determine which kinds of competencies employers and lecturers value the most in the fields of science and engineering. The study found good alignment between employer expectations and lecturer expectations. However, key gaps between employer expectations and graduate competencies were noted, including written communication, problem solving, critical thinking and self-management skills.

Other studies were conducted concerning migrant workers and non-English-first-language speakers. Wolfe, Shanmugaraj and Snipe (2016) surveyed 169 businessmen and found that businessmen are generally forgiving of grammatical errors commonly exhibited by employees who are non-English-first-language speakers yet far less forgiving if their workers are English-first-language speakers. Businessmen are, however, highly conscious of sensitive aspects such as tone and politeness in written communication, even from non-English-first-language employees. Fernando, Almeida and Dharmage (2016) performed a broader analysis on the diversity of new employees in Australia, including migrant workers. The study found that larger companies with young employees in middle to upper management were far more accepting of diverse graduates than smaller companies or companies dominated by older generations of employees who often exhibit various prejudices. Large firms are able to absorb shortcomings associated with diversity, non-English-first-language speakers, various cultures and nationalities. However, smaller firms which have ambitions of growth and strive to be highly efficient find diversity burdensome. Smaller firms also have less funds and resources to provide training and group exercises to mitigate shortcomings associated with diversity (Almeida et al., 2015).

Engineering firms were found to be particularly concerned about the drop in the quality of written communication. While other businesses often require subjective writing, the nature of technical reporting in engineering fields requires significantly more clarity and precision.

Employers of engineers were not only the most vocal and unanimous in this complaint against new graduates, but also the most sceptical of language proficiency training courses (Knoch, May, Macqueen, Pill and Storch, 2013; Wolfe et al., 2016). Concerning graduate opinion, Itani and Srour (2016) conducted a qualitative investigation which found that engineering graduate and student emphasis on soft skills, such as oral and written technical communication, were found to generally be low and dependent mainly on students' career aspirations. Aspirations of simply getting employed and getting that starting salary as a steady income often caused students to emphasise the technical courses of the curriculum and neglect soft skills, while students who had a mature plan and aspiration to not only get a job but progress in that job, tended to leave no aspect underemphasised in their studies.

A more comprehensive quantitative study was conducted by Fletcher, Sharif and Haw (2017) who surveyed chemical engineering final-year students, graduates and people employed in industry, specifically in chemical engineering workplace roles. The study attempted to compare trends in employer satisfaction and key competencies. It was revealed that alignment between employer expectations and new graduate capabilities have improved in comparison to 2004. It was indicated that accredited engineering schools in the United Kingdom have endeavoured, with considerable effort, to improve upon the general and transferable skills of graduates. Technical skills were consistently ranked low on the agenda of respondents who were employed in chemical engineering roles, due to the presence of formal or informal company training programmes that teach technical skills pertaining to their particular industry. However, transferable skills such as communication, reporting, teamwork, information technology as well as entrepreneurship and business acumen were found to be highly valued and often lacking in graduates, although less so than in previous years.

The study correlated well with a previous Australian study by Nair, Patil and Mertova (2009) who categorised global engineering competencies into a 3D model of "Hard Skills", "Global Skills" and "Soft Skills". The study found leadership, communication, social ethics, interpersonal and problem-solving skills to be of high value and often lacking in many graduates. A later study by Radermacher and Walia (2013) on computer engineers in the USA also indicated communication, teamwork and management skills, as well as ethics to be lacking in many graduates.

A more sophisticated study was conducted in Malaysia by Osman, Naam, Omar, Jamaluddin, Kofli, Ayub and Johar (2013) who utilised an opportunity of industrial training to retrieve employer perceptions. Nearly 280 engineering students were put through an industrial training programme and 20 employees from various companies were sought to witness student performance during the programme and answer a quantitative survey consisting of 20 questions. Overall, company employees were satisfied with students' performance. However, while employees rated students well for technical ability, confidence and leadership skills were found to be lacking in most students.

2.7 Conclusion

This literature review was conducted to assess the current situation in terms of engineering employment in South Africa, graduate throughput issues, benchmarks of graduate quality and the context of UKZN. Relevant frameworks have been identified, with the Biggs study motives and strategies framework having high relevance in the research methodology, while Bloom's taxonomy and Boundaryless and Protean careers form key points of discussion in interviews and when analysing results in this study. Other contemporary research efforts in the area of engineering education, graduate expectations and employer expectations have been reviewed, thereby revealing that the challenges, questions and issues raised in this work are not unique to the context of this study, but widespread in other countries and settings and numerous simple to complex solutions are being constantly investigated. The issues and frameworks found in this review have been the basis of the research methodology developed in this research, which is discussed in the next chapter.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

The previous chapter introduced the topic and the frameworks relevant to this study, together with previous efforts to assess and address various issues in engineering education and its alignment with industry needs. The key frameworks found in this study were Bloom's taxonomy (Bloom et al., 1956), Bigg's study motives and strategies (Biggs, 1987) and Boundaryless and Protean careers (Briscoe and Hall, 2006). While all frameworks were found to be relevant, the most useful framework for quantitative assessment was found to be the Bigg's study motives and strategies framework, since it was rigorous and more positivist in its approach.

This chapter reiterates the aim of this study and presents the research paradigm that governs the research design. The population sample and the sampling approach are then discussed, followed by a rationale of the survey instrument's construction. Data collection and analysis are then presented, followed by a discussion concerning the credibility, reliability and validity of the data and information obtained. Matters pertaining to ethical clearance conclude the chapter.

3.2 Aim of the Study

The aim and objectives of the study are explained in Chapter 1, Section 1.6 of this dissertation. The first objective was to determine the work expectations of newly-graduated UKZN engineering students. This was accomplished by issuing a questionnaire to a sample of graduates during the graduation ceremony. The questionnaire produced biographical information about each respondent. In order to understand where the graduate's expectations emanate from, it was regarded as necessary to include the Biggs SPQ (Biggs, 2001), followed by open-ended questions requiring written responses.

The next two objectives concerned determining engineering employers' expectations of newly employed graduates and identifying any trends that employers have observed over time about new graduates. To accomplish these, it was decided to interview Academic leaders in each engineering discipline at UKZN. An interview schedule was drawn up and used in a recorded, semi-structured interview.

The final objective was to establish ways in which UKZN could assist in bridging any gaps between graduate and employer expectations and reality. This was accomplished by assessing and comparing graduate questionnaire responses to that of Academic Leader interview responses.

Lastly, triangulation of data was attempted by utilizing data from UKZN QPA Graduate Opinion Surveys (QPA, 2019), in order to add further certainty and confirm credibility of the findings.

3.3 Research Paradigm and Design

There are a number of research paradigms that were considered in approaching the topic of this study. Of the research paradigms considered, the two selected include the positivist and interpretivist research paradigms.

3.3.1 Positivism and Quantitative Research

The positivist paradigm is one in which empirical testing occurs with a belief that the findings of a constrained study can be reasonably generalised to other situations and environments. This paradigm is a popular choice for pure scientific studies yet can also be utilised within reason in the social sciences and other studies involving the quantitative surveying of respondents' opinions, provided that the validity or limitations of validity are clearly expressed in a probabilistic sense. In quantitative research, the credibility of responses and results increases with the number of respondents surveyed and the reasonable diversity of respondents (Antwi and Kasim, 2015; Gemma, 2018; Cowling, 2016).

3.3.2 Interpretivism and Qualitative Research

Qualitative research adopts an interpretivist approach which rejects predefined probabilistic models and attempts to assess the quality and validity of responses based on the applicability of respondents in relation to the study. Respondents' opinions and behaviour are sought or studied from their daily life and not in a controlled setting. Similar to interpretivism, the constructivist paradigm asserts that people construct their own views of reality based on their surroundings, regardless of prevailing positivist statistics (Chowdhury, 2014; Antwi and Kasim, 2015).

Combinations of elements of the positivist and interpretivist research paradigm in any research methodology is seen as “mixed-methods” research, including quantitative and qualitative methods, probability and non-probability sampling (Gemma, 2018; Cowling, 2016).

3.3.3 Approach Used in this Research

Bearing in mind that the study drew from two very different types of audiences, it was determined that neither positivism nor interpretivism alone would be an adequate research paradigm. Assessing graduate opinions and expectations required the participation of a high number of graduates in order for the findings to be credible. Graduate biographical information, general opinions, motives for pursuing engineering as a career and graduate learning strategies were processed and collated using a positivist approach. For added value, a new and condensed version of the Biggs (1987) questionnaire was included to determine the depth of graduates' motives in their pursuit of an engineering career. According to Biggs (2001), quantitative results using standardised questions within the Biggs study motives and strategies framework also tie in with a positivist approach.

Graduates' career expectations as qualified engineers were also probed in an open-ended manner, rather than through a choice of predetermined solution options. Written responses gained through a mixed methods approach made it possible to categorise common responses and achieve a positivist element to the study, although responses were written naturally in a variety of ways.

Obtaining the insights of industry entailed overcoming different constraints. Credibility of information depended not on how large the sample size was, but on the quality of the persons in the survey in terms of their wide-ranging experience and credible insight relevant to the topic of this study. This placed high constraints on finding available and willing participants which lent credence to a more interpretivist approach. Qualitative data were obtained in this regard, where responses from such personnel were taken seriously no matter how contradictory they may have seemed, without attempting to control the responses to establish a trend or model (Cowling, 2016).

The ideal profile of interview candidates would be middle to senior managers of major companies that employ significant numbers of graduate engineers. Such a profile, however, was found to be too narrow as each response would be relevant only to the particular company where the respondent was employed. Establishing employer expectations of graduates would thus require a large sample of such respondents in order to achieve an adequately broad and encompassing picture. This was beyond the resources of this study. Academic leaders of each engineering discipline at UKZN possessed the necessary experience and insight due to their liaison with multiple industry partners through regular IAB meetings and involvement in certain assessments; this study aimed therefore to conduct semi-structured interviews with Academic leaders of all engineering disciplines at UKZN.

3.4 Population and Sample

A sample can be described as a group of people that are a representative subset of a wider population to be researched (Murgan, 2015). Sampling methods in general can be categorised as either probability sampling or non-probability sampling. With probability sampling, everyone in a population has a chance of being sampled, whereas with non-probability sampling, some of the population has been excluded from the sample and often the exact number of people excluded cannot be calculated (Babbie and Mouton, 2012).

There are various types of probability sampling, including simple random sampling, stratified sampling and systematic sampling. Non-probability sampling methods include convenience sampling, quota sampling and purposive sampling (Murgan, 2015; Babbie and Mouton, 2012). Sampling methods relevant to this work are discussed herein.

Given the time constraints, graduates were surveyed by issuing each of them with a written questionnaire. Given the limited availability of graduates (who no longer congregated on campus), it was decided to take advantage of the convenience sampling approach, where a population is surveyed at a convenient opportunity advantageous to the study (Babbie and Mouton, 2012). In this case, graduate questionnaires were administered physically to graduates during the 3rd April 2019 graduation ceremony to ensure a high level of participation. This strategy ensured not only a potentially large sample size but also complete diversity as graduates of all engineering disciplines and backgrounds were present to be surveyed.

The aim was to survey 120 graduates out of a population of 393 graduates present at the 3rd April 2019 Engineering Graduation Ceremony (QPA, 2019). The method of sampling these 120 graduates was one of stratified probability sampling, with the aim of surveying at least 20 graduates from each engineering discipline as a subset to get a representative sample of all types of engineering graduates at UKZN (Bhat, 2019). However, when considering the 20 questionnaires handed out to each discipline, random probability sampling was observed.

Respondents were recruited in person, as all graduates were seated in a highly controlled order, each with a seating number. Thus, samples from each engineering discipline were identified and asked to participate. Hard copy questionnaires were handed out together with a complimentary pen. Respondents were given the full duration of the ceremony (approximately two hours) to complete the questionnaire. Questionnaires were then collected.

Regarding interviews of academic leaders, the sample was highly specific. Academic leaders in charge of each engineering discipline at UKZN were to be interviewed. While there are seven disciplines of engineering at UKZN, there were only four academic leaders since there is one academic leader representing electrical, electronic and computer engineering and one academic leader representing civil and agricultural engineering. Chemical and mechanical engineering disciplines each have their own academic leaders. Where unavailability of an academic leader prevailed, active personnel who previously occupied the position were sought.

All respondents in this study were provided with a consent form (Appendix A and B) to sign and return for safe-keeping. All forms are retained in accordance with UKZN's Research Ethics Policy.

3.5 Construction of Survey Instruments

Graduates were surveyed using printed questionnaires. The questionnaire is available in Appendix C. The questionnaire contained three sections.

Section A formed a biographical section and contained 13 multiple-choice questions pertaining to graduates' backgrounds. Questions concerning their age group, race, gender, home and second language and field of engineering were asked. Questions concerning whether graduates worked while studying and ran their own household while studying, graduates' current employment status, as well as the most and least relevant factors that contribute to them accepting a job offer were asked. As mentioned in Chapter 2, students' motives and strategies are not necessarily a product of the graduate alone but could also be a product of how modules are run and assessed, as well as the general pressure that the graduate was under during the study period. In an ideal case, deep motives and strategies are highly preferred. However, a student's general life and background can introduce pressure that causes them to strategically choose surface motives and strategies. Section A of the questionnaire thus aims to ascertain any background factors which might account for how the graduate approached studying towards his career.

Section B of the questionnaire contained a set of 23 questions, 20 of which are from the condensed version of the Biggs (1987) questionnaire developed by Biggs (2001). The Biggs (1987) questionnaire, framework and later versions have been discussed in Chapter 2. The set of questions required responses represented by numbers, where "1" represents "Never or only rarely true of me" up to "5" which represents "Always or almost always true of me". The questions attempted to cross-examine graduate's motives and strategies for studying their engineering degree. The extent of deep or surface learning is gauged, as well as the extent of deep or surface strategies.

The final section, Section C, contained a written component where graduates were asked open-ended questions about aspects such as what the best parts of their degree were, why they chose a degree in engineering, short and long term career goals, employment prospects and options and general attitude towards entering the workplace.

The combination of multiple-choice and open-ended questions was intended to provide quantitative as well as qualitative insight into graduates' expectations for their career and the future. The complete questionnaire is available in Appendix C.

The interview schedule (Appendix D) consisted of 17 questions developed to probe respondents on the themes of graduate expectations of the workplace, employer expectations of graduates, trends in new graduate employees, mentorships and EIT programmes, ECSA exit-level outcomes (ELOs), the extent of industry participation in academia, external workshops and courses for continuous professional development. The interview was designed to last no longer than an hour so as not to burden the respondent. Respondents were interviewed in their work office in a one-on-one interview. The interviews were semi-structured, including follow-up questions depending on respondents' responses and taking redundancy into account. Details of each interview are available in Table 3.1.

Graduate questionnaire questions and academic leaders interview questions were developed consultatively within the time constraints of this study. However, due to the strategy of convenience sampling at the graduation event, use of hardcopy questionnaires and limited availability of academic leaders for interviews, circumstances did not allow a pilot study to be conducted within the normal time provided for such a study. Measures to improvise on the circumstances were taken in the form of abundant opportunity for open-ended points and semi-structured discussion to be made in questionnaire and interview cases respectively.

The QPA Graduate Opinion Survey instrument was developed and is administered wholly by QPA with no input from this study whatsoever. This study however used results published by QPA as a secondary source of data to achieve triangulation of information.

3.6 Data Collection Methods

Graduate questionnaires were administered and collected as hardcopies. Responses were manually entered into a Microsoft Excel Spreadsheet for statistical analysis. This proved to be easy for Sections A and B of the questionnaire. While Section C of the questionnaire contained some open-ended questions, it was anticipated that the responses of the open-ended questions may have limited variance, in which case such information was recorded in an Excel spreadsheet as well.

Section B was further analysed using the Biggs (2001) study process algorithm to assess graduates' attitude, work ethic and mentality as they enter the workplace. The details of this are presented in Section 3.7.

Data and information collected from the QPA Graduate Opinion Survey was made available in a report by QPA (QPA, 2019). This formed a secondary source of information on graduate opinions. Interview responses of academic leaders were conducted in a private setting, the respondents' offices, on a one-on-one basis. Details of each interview are provided in Table 3.1

Table 3.1: Interview Respondent Profiles

Respondent	Date Interviewed	Position at UKZN	Years in Position	Years employed at UKZN	Total Years of Engineering Experience
R1	8/10/2019	An academic leader in a UKZN engineering discipline/cluster	2	>10	20
R2	10/10/2019	An academic leader in a UKZN engineering discipline/cluster	2	9	15
R3	17/10/2019	An executive leader at the UKZN School of Engineering	2	>12	>20
R4	23/10/2019	An academic leader in a UKZN engineering discipline/cluster	3	>10	>15

All respondents gave consent to being recorded. Each interview was thus recorded using a professional recording device as well as a mobile phone recorder as a backup device. Recordings were recorded in WAV format, transcribed using voice-to-text software and edited where required.

3.7 Analysis of Data

Analysis of results obtained from the questionnaire developed in this study was attempted using MS Excel, with QPA results being used merely for comparison and further discussion. Interviews were recorded and transcribed using Amberscript software and MS Word.

3.7.1 Graduate Survey Data

Regarding the questionnaire developed in this study, all responses were entered into an excel spreadsheet for each respondent in each year and statistical analysis was performed. For the first 13 multiple-choice questions, the statistical analysis involved establishing percentages of responses, which may be further analyzed by comparing the results for each year, gender, race group or other social grouping.

For the next 20 questions concerning the Biggs (2001) SPQ, the analysis was substantially more complex than simple statistical analysis of biographical information. The analysis was, however, much simpler than for the original Biggs (1987) questionnaire. In this study, the condensed version of the questionnaire was used, which ignored attempts to establish "Achieving" motives and strategies, but rather focused on trying to categorize respondents' motives and strategies as either "Deep" or "Surface". The questions were staggered in a purposeful, structured order in an attempt to cross examine respondents' responses.

The questions measured in the following manner:

Question 1: Extent of Deep Motive
Question 2: Extent of Deep Strategy
Question 3: Extent of Surface Motive
Question 4: Extent of Surface Strategy
Question 5: Extent of Deep Motive (repeated, but asked in a different manner)
Question 6: Extent of Deep Strategy
Etc.….. (Repeated)

Each question required numerical responses, ranging from one to five, which was used in a score mechanism. For example, for each respondent the responses for questions "1", "5", "9", "13" and "17" were summed to provide a score measuring the extent of Deep Motive. Responses for questions "2", "6", "10", "14" and "18" were summed to provide a score measuring the extent of Deep Strategy. In the same manner, extent of Surface Motive was determined by summing responses for questions "3", "7", "11", "15" and "19" and the extent of Surface Strategy was determined by summing responses for questions "4", "8", "12", "16" and "20".

In this study, as per the intended use of the Biggs' (2001) condensed questionnaire, motives and strategies were not assessed individually. Scores for Deep Motive and Deep Strategy were further summed to establish the extent of Deep Approach, while scores for Surface Motive and Surface Strategy were summed to establish the extent of Surface Approach by each respondent.

Since responses to individual questions ranged from "1" to "5", cumulative scores could range from 10 to 50 for each approach. These scores could be analyzed as a percentage out of a maximum 50, or further converted into decile scores for appropriate categorization. Biggs (1987) contains tabulated guidelines for converting all scores into decile scores for different career fields including science, art and education. These scores were adapted for this study using a factor of 0.71 (50/70).

Decile scores were then used to categorize approaches. It is too simplistic to categorize respondents to have an either deep or surface approach. The endeavour instead was to determine the extent of deep or surface approaches by determining whether the respondent was collectively affirmative, neutral, or negative towards questions pertaining to deep or surface approaches. The decile scores of each approach were thus converted into three categories as shown in Table 3.2. Responses were then categorized together by looking at the ranges together.

Each respondent was thus categorized according to Table 3.3. Exclusively Deep Approaches denoted an exclusive affinity for deep motives for pursuing the chosen career and its associated study modules and deep strategies to study for success not only in obtaining the degree but in gaining an in-depth understanding for a successful career. Predominant, moderate and mixed approaches were indicative of mixed motives and strategies based on various factors such as respondents' varying interest in certain modules of their degree, varying assessment methods and varying pressure to succeed which may change learning strategies.

Table 3.2: Biggs SPQ Decile Score Ranges

Decile Scaled Score	Approaches		Broad Category	
	Surface	Deep	Surface	Deep
10	39+	41+	"+"	"+"
9	37-38	37-40		
8	35-36	35-36	"0"	"0"
7	33-34	33-34		
6	32	31-32		
5	31	30		
4	29-30	28-29		
3	26-28	26-27	"-"	"-"
2	24-25	25		
1	0-23	0-24		

A single approach could not be determined for respondents who did not answer consistently. Some students indicated deep approaches to certain aspects of their degree and surface approaches to other aspects with a desire just to pass. These respondents had an approach range of “+” for both deep and surface approaches. A similar case arises for respondents with “-” for both deep and surface approaches, though responding to the questions negatively.

Table 3.3: Biggs Study Approaches

Approaches		Combined Description
Deep	**Surface**	
"+"	"-"	Exclusively Deep approach
"-"	"+"	Exclusively Surface approach
"0"	"-"	Moderately Deep approach
"0"	"0"	Mixed approach
"-"	"0"	Moderately Surface approach
"+"	"0"	Predominantly Deep approach
"0"	"+"	Predominantly Surface approach
"+"	"+"	Undetermined
"-"	"-"	Undetermined

In addition to the Biggs (2001) questionnaire, three further questions were asked to gauge respondents’ confidence moving forward. Respondents were asked to rate their confidence in tackling unfamiliar problems, planning their own work and sourcing quality information, which are highly important abilities new graduates need to possess in order to further learn and perform their employment duties thoroughly and competently.

Section C questions were more difficult to analyze because they required written responses rather than multiple-choice questions, decided on since respondents may very easily have selected the ideal choice if multiple-choice options were given. Written responses required the respondent’s knowledge and opinion, gave them freedom to answer in a manner reflecting their thoughts and encouraged greater honesty in their responses. While the responses were written, it was possible to categorize the answers to each question. Responses could thus be tabulated and analyzed statistically in an Excel spreadsheet as well.

3.7.2 Academic Leader Survey Data

While the graduate survey responses could be placed in a spreadsheet for analysis, interview responses were analysed directly for what they were, since the responses were qualitative. Interviews were transcribed and thematic analysis was conducted, in which various themes of the interview conversations were identified (Nowell, Norris, White and Moules, 2017; Caulfield, 2019). A deductive approach was firstly applied, seeking information specifically on the following themes:

- Employment and work expectations of graduates
- Employer expectations of new graduates
- Mismatches between engineering curricula and industry needs
- Postgraduate qualification
- EIT-programme availability, structure and assessment
- ECSA ELO's and Attributes
- Further training and upskilling courses
- Skills and knowledge gaps and overemphasis
- Company participation in UKZN engineering programmes
- Employer teaching and learning advice
- Suggestions on bridging the gaps

Further probing occurred during interviews, which inductively uncovered themes concerning engineering workloads, vacation work opportunities, graduate confidence and lack of engineering background. A semantic approach was generally observed, where data was analyzed explicitly and without delving extensively into subtext and underlying assumptions (Caulfield, 2019). The statistical results of the graduate questionnaire were compared to the actual responses of the academic leaders who were interviewed.

3.8 Credibility, Reliability and Validity

Numerous efforts were made to ensure the validity and reliability of the quantitative survey and the credibility and trustworthiness of the qualitative survey. As mentioned in Section 3.4, convenience sampling was selected for surveying the engineering graduates. A population of 393 graduates was available and 120 graduates were approached as the sample size of the total population (30.5% of the 2019 population of UKZN engineering graduates). However, due to various reasons discussed in Chapter 4, the response rate was low. Fifty responses were received out of a potential 120 questionnaires handed out. It is important to note however, that the response rate of the survey in this study was not abnormally low and was comparable to response rates achieved by the annual QPA Graduate Opinion Survey (QPA, 2019).

Despite the above, the survey achieved good diversity of opinion in terms of the fields of engineering in which the graduates practise, which enhances the reliability of the results. There was also high diversity in the employment status of respondents as shown in Table 4.2 of

Chapter 4, thereby achieving a diverse array of responses regarding graduate expectation of the workplace.

While Sections A and B were well answered by respondents, Section C endured an even lower response rate, possibly because it required written responses which many respondents were unwilling to do. Thus all statistical analysis of Section C responses were made in relation to the number of people who responded to each question, not simply the total number of responses.

Nevertheless, all respondents were given ample time of at least two hours in which to respond, with high assurance of the confidentiality and anonymity of their responses, thereby eliminating doubt as to the truthfulness, reliability and validity of their responses. The validity of quantitative results was further bolstered through the incorporation of the QPA Graduate Opinion Survey results as a secondary source of information for broader comparison (QPA, 2019). Students who have graduated possess more credible opinions since they've experienced the entire engineering programme, while younger cohorts have not completed all modules.

The credibility and trustworthiness of interview responses in this study is directly tied to the credentials and profile of the interview respondents. Four respondents were interviewed as previously mentioned and their profiles are provided in Table 3.1. Respondents were selected based on their position of academic leader.

While technically the respondents have been in their current position for relatively few years, all respondents have numerous total years of experience at UKZN and otherwise in managerial roles interacting with IABs. It is also important to note that while Respondent R3 is currently not a discipline academic leader, R3 was previously in the position for many years and is currently still an executive leader at UKZN Engineering.

Academic leader responses indicated that each engineering discipline conducts IAB meetings on an annual or bi-annual basis. The advisory board for each engineering discipline was declared by academic leaders to be composed of representatives from at least three major employers. In all cases, employers did not remain on the board all the time. There was often rotation and addition of more members depending on availability. Beyond the advisory board, employers also engage closely with each discipline through serving as external examiners for module assessments, presentations, practicals and final-year design projects. Thus, while it was unachievable in this study to directly interview employers, the strategy of interviewing academic leaders as a proxy for engineering employer opinions and expectations was found to be highly credible, trustworthy and provided numerous benefits discussed in Section 6.2.

3.9 Ethical Considerations

All survey responses, including graduate questionnaires and interview responses, were treated with utmost confidentiality, thereby maintaining anonymity of all respondents. This is of primary importance in the ethics of surveying, as respondents are providing their participation voluntarily in order to make the research possible (Kothari, 2013).

Undertaking the research methodology described herein required a gatekeeper's letter, which was obtained from the Registrar of UKZN. Ethical clearance was applied for to the UKZN Research Office Ethics Committee. A two-part application was made, for the surveying of graduates during the graduation ceremony and for interviewing academic leaders. The gatekeeper's letter and both ethical clearance approval letters are contained in Appendix E.

Graduate questionnaires and academic leader interview schedules contained informed consent letters which were signed by participants to ensure voluntary participation and that no coercion had taken place. Clear explanations of the study were provided (Berg, 2014). The explanations and informed consent letters are available in Appendix A and Appendix B. While respondents provided their names and signatures to the consent forms, they were assured that all reporting and usage of responses will not be identified with them personally. This practice is not only ethical but also removes any reservations of bias in participants and grants them freedom to answer honestly and frankly where appropriate (Creswell, 2014). Academic leader interviews were recorded with the full permission and awareness of respondents. Where respondents made controversial remarks directed at certain companies during interviews, company names were replaced by generic markers "Company X" and "Company Y" etc. in this dissertation.

3.10 Conclusion

This chapter presents all aspects pertaining to the research methodology used in this study. A mixed-methods approach was adopted, with positivist and interpretivist approaches utilized, which ultimately translated into quantitative and qualitative surveying of engineering graduates and discipline academic leaders. The sampling approach, construction of survey instruments, data collection and data-analysis methods were explained together with the consideration of the credibility, validity and reliability of results and responses. Lastly, ethical considerations were explained. The following chapters contain a presentation and discussion of results, followed by the main conclusions.

CHAPTER 4: PRESENTATION OF RESULTS

4.1 Introduction

Chapter 2 introduced the relevance of this study and the frameworks identified which may be used to assess results. The research methodology was then explained in detail in Chapter 3, including the graduate survey conducted using questionnaires, the use of the QPA (2019) Graduate Opinion Survey results for comparison and academic leader survey conducted through recorded one-on-one interviews. Chapter 4 contains a presentation of the results of all aspects of this research.

The chapter firstly presents tabulated biographical statistics of the respondents to the graduate questionnaire. Employment and job factor statistics are presented thereafter, which concludes the results of Section A of the graduate questionnaire. Where appropriate, results are compared with the results of the QPA (2019) Graduate Opinion Survey, which is used as a secondary source in this study. Statistics for Section B are then presented, as a result of the Biggs algorithm explained in Section 3.7. Statistics detailing graduate approaches are presented together with response statistics to each statement in Section B. Graduates' written responses are then presented. In all cases, key statistics have been emphasized. Responses from interviews with academic leaders are lastly presented in the form of text and direct quotes.

4.2 Biographical Information

A total of 120 questionnaires were handed out during the April 2019 Engineering Graduation at UKZN. The aim was to issue at least 20 questionnaires to respondents of each Discipline of Engineering. Each respondent was handed a hardcopy of the questionnaire and a complimentary pen to fill it in. Unfortunately a low response rate was achieved with most respondents unwilling to participate. Only 50 respondents participated, resulting in a response rate of 42%. Respondents were also even less willing to answer written responses and the response rate of this section in particular was lower than the rest of the questionnaire. Reasons for this are discussed in Section 5.2. Table 4.1 presents the demographics of the respondents of the graduate survey.

Table 4.1: Demographics

Graduate Age	**Number**	**%**
18 to 21	1	2
22 to 25	41	82
26 to 35	7	14
36 to 45	1	2
Above 45	0	0
Graduate Race	**Number**	**%**
Black	11	22
White	5	10
Coloured	0	0
Indian	34	68
Other	0	0
Gender	**Number**	**%**
Male	33	66
Female	17	34
Home Language	**Number**	**%**
English	39	78
Zulu	8	16
Afrikaans	0	0
Other South African Language	1	2
International Language	2	4
Second Language	**Number**	**%**
English	15	30
Zulu	1	2
Afrikaans	30	60
Other SA Lang	0	0
International Lang	4	8
Field of Engineering	**Number**	**%**
Agricultural Engineering	4	8
Chemical Engineering	16	32
Civil Engineering	9	18
Electrical/Electronic/Computer Engineering	13	26
Mechanical Engineering	8	16

The highest number of respondents was from the discipline of Chemical Engineering, followed by Electrical, Electronic and Computer Engineering, Civil Engineering, Mechanical Engineering and lastly Agricultural Engineering. The majority of respondents (82%) were of the age 22 to 25, with 14% in the range of 26 to 35 and one respondent in each of the ranges, 18 to 21 and 36 to 45 years old.

Twenty two percent of respondents did not speak English as their home language, which is of great importance for undergraduate educators to consider in assessments, especially since this figure is expected to rise. The QPA Graduate Opinion Survey (QPA, 2019) revealed that university-wide, 63% of graduates do not speak English as their first language, while in the College of Agriculture, Engineering and Science 53.4% do not speak English as their first language.

For this survey, 68% of respondents were Indian while 22% were black and 10% white. However, 35% of respondents of the QPA (2019) survey were Indian, 58% black and 5% white. With UKZN being situated in Durban where a large population of Indians reside, it is understandable to have a higher proportion of Indian graduates compared to other parts of South Africa. It is however encouraging from the QPA (2019) survey that a large number of engineering graduates are blacks as it more closely reflects the demographics of the country. Another encouraging statistic is that for this survey 34% of respondents were female; for the QPA (2019) survey nearly 54% of respondents were female.

4.3 Employment and Job Factor Statistics

Table 4.2 presents employment and job factor statistics for the responses of Section A in the graduate questionnaire. Of particular importance to consider was that despite the demanding workload that engineering degrees entail, 24% of respondents worked while studying and for 14% work was absolutely necessary while studying. Furthermore, 24% of respondents ran their own household while studying. These factors certainly place constraints on time available for in-depth pursuit of undergraduate studies. The Graduate Opinion Survey (QPA, 2019) found that 15% of graduates in the college of Agriculture, Engineering and Science were self-funded during their undergraduate study.

Encouragingly, 50% of respondents had been offered a job and 44% had already accepted. Of concern, however, are the other statistics. Unemployed respondents, still looking for a job, totalled 36% and only 12% had chosen to pursue postgraduate study. Of greatest concern was that at that stage, only one respondent indicated an ambition to start a business right away.

Table 4.2: Employment and Job Factor Information

Did the Graduate Work while studying?	**Number**	**%**
Yes	12	24
No	38	76
Was Work Necessary while Studying?	**Number**	**%**
Yes	7	14
No	43	86
Did the Graduate Run his/her own Household while Studying?	**Number**	**%**
Yes	12	24
No	38	76
Graduate Employment Status	**Number**	**%**
Offered a job and accepted	22	44
Offered a job but not accepted yet	3	6
Unemployed and looking for a job	18	36
Pursuing Postgraduate study	6	12
Trying to start a business	1	2
Most Important Factor for Job Acceptance	**Number**	**%**
High remuneration offer	5	10
Proximity to current city of residence	3	6
Growth opportunities in a company	21	43
Alignment to field of study	13	27
Long term employment certainty	7	14
Second Most Important Factor for Job Acceptance	**Number**	**%**
High remuneration offer	14	29
Proximity to current city of residence	5	10
Growth opportunities in a company	11	22
Alignment to field of study	8	16
Long term employment certainty	11	22
Least Important Factor for Job Acceptance	**Number**	**%**
High remuneration offer	7	14
Proximity to current city of residence	26	52
Growth opportunities in a company	1	2
Alignment to field of study	8	16
Long term employment certainty	8	16

On a broader note, the Graduate Opinion Survey conducted by QPA (2019) revealed that for the School of Engineering, 48% of respondents described themselves as employed, with 1.4% describing themselves as self-employed. 18.7%, indicated they were studying further.

A large number of respondents (43%) listed “growth opportunities in the company” as the most important factor for them accepting a job, which is a prudent priority. Also highly encouraging is that proximity to current place of residence was the least selected priority, indicating high employee mobility and willingness to relocate for the sake of job opportunities. It is further encouraging to note that only 14% want long-term employment certainty. Long-term employment certainty is becoming increasingly rare with high job mobility and the “gig economy” becoming increasingly prevalent. Respondents thus seem willing to relocate for a job offer and are fine to continue relocating for further job offers. Those wanting strong alignment to their field of study comprised 27%.

While growth opportunities in a company stood out as graduates’ most common priority, when asked regarding the second most important factor for job acceptance there was a much more even spread of opinion, with 29% expressing a desire for high remuneration. While many did not cite growth opportunities as the first priority, 22% of respondents cited it as their second priority. Collectively, 64% of respondents listed growth opportunities in a company as either first or second priority. Proximity to one’s residence remained of low importance to respondents while 22% of respondents cited long-term-employment certainty as second priority. Many of those who selected this option selected growth as their first priority.

The question of the least important factor in job searching mirrored that of the most important factor, in that 52% of respondents clearly stated that proximity to current residence is of lowest priority while only 2% indicated growth opportunities as their least important factor.

No discernible trend could be established regarding respondents’ field of study and respondents’ priorities when accepting a job. Priorities regarding job acceptance are thus to be regarded as universal across all disciplines, with no particular engineering discipline having respondents with particular and similar desires.

4.4 Graduate Study Motives and Strategies

Table 4.3 and Table 4.4 present statistics for Section B of the questionnaire, which addressed graduates’ study process in order to obtain their degrees. All fifty respondents provided responses to this section. The method of assessing responses and categorising respondent approaches was explained in detail in Chapter 3.

Table 4.3: Study Process Questionnaire Approach Statistics

Approach Description	Number	%
Exclusively Deep approach	17	34
Predominantly Deep approach	1	2
Moderately deep approach	16	32
Exclusively Surface approach	2	4
Predominantly Surface approach	2	4
Moderately Surface approach	5	10
Moderately Mixed Approach	2	4
Undetermined	5	10
Total	50	100

It was found that 34% of respondents exhibited an exclusively deep approach to their studies and pursuit of their degree. This category is mostly a positive approach and an encouraging find. It indicates that the teaching and delivery of modules in the University engineering program is instilling deep motivations in graduates for their career. It suggests graduates like what they have studied and are interested in their work. Table 4.4 indicates that, collectively, 56% of respondents answered either "Always True" or "Frequently True" when asked if studying gave them a feeling of deep personal satisfaction. Sixty two percent were interested in doing enough work and forming their conclusions by themselves before being satisfied with their level of knowledge.

For 32% of respondents, at least half of the time they believed that lecturers should not have expected them to spend time studying material that everyone knows will not be examined. Twenty two percent believed this to be frequently true.

General interest was also consistent. Statement 11 for example, which read: *"I found that I could get by in most assessments by memorising key sections rather than trying understand them"*, was met with disagreement in 70% of respondents, which was consistent with respondents agreement of statement "2" which read: *"I found that I had to do enough work on a topic so that I can form my own conclusions before being satisfied"; a*nd statement "10" which read: *"I tested myself on important topics until I understood them completely"*.

A concerning finding was that for statement "8", 22% of respondents indicated that they learned things by rote most of the time (memorising aspects by heart rather than understanding them). Twenty four percent indicated this to be the case at least half of the time. In response to statement "20", 38% believed in remembering answers to likely questions in exams as a strategy to pursue at least half of the time.

Table 4.4: SPQ Responses

Question		Always true	Frequently True	True half of the time	Sometimes true	Never or rarely true
1. I found that at times studying gave me a feeling of deep personal satisfaction.	Number	9	19	11	9	2
	Percentage	18	38	22	18	4
2. I found that I had to do enough work on a topic so that I can form my own conclusions before being satisfied.	Number	12	19	13	5	1
	Percentage	24	38	26	10	2
3. My aim was to pass the course while doing as little work as possible.	Number	3	6	5	15	21
	Percentage	6	12	10	30	42
4. I only studied seriously on what was given out in class or in the course outlines.	Number	1	10	11	11	17
	Percentage	2	20	22	22	34
5. I now feel that virtually any topic can be highly interesting once I get into it.	Number	10	24	11	4	1
	Percentage	20	48	22	8	2
6. I found most topics interesting and often spent extra time trying to obtain more information about them.	Number	8	14	16	10	2
	Percentage	16	28	32	20	4
7. I did not find my course very interesting so I kept my work to the minimum.	Number	2	5	6	12	25
	Percentage	4	10	12	24	50
8. I learned some things by rote, going over and over them until I knew them by heart even if I didn't understand it.	Number	1	10	12	10	17
	Percentage	2	20	24	20	34
9. I found that studying academic topics could at times be as exciting as a good novel or movie.	Number	5	13	18	7	7
	Percentage	10	26	36	14	14
10. I tested myself on important topics until I understood them completely.	Number	12	19	11	6	2
	Percentage	24	38	22	12	4
11. I found that I could get by in most assessments by memorising key sections rather than trying understand them.	Number	0	5	10	18	17
	Percentage	0	10	20	36	34
12. I generally restricted my study to what was specifically set as I thought it unnecessary to do anything extra	Number	3	7	18	12	10
	Percentage	6	14	36	24	20

Table 4.4 (Continued): SPQ Responses

Question		Always true	Frequently True	True half of the time	Sometimes true	Never or rarely true
12. I generally restricted my study to what was specifically set as I thought it unnecessary to do anything extra.	Number	3	7	18	12	10
	Percentage	6	14	36	24	20
13. I worked hard at my studies because I found the material interesting.	Number	9	14	16	6	5
	Percentage	18	28	32	12	10
14. I spent a lot of my free time finding out more about interesting topics which were discussed in different classes.	Number	4	10	11	17	8
	Percentage	8	20	22	34	16
15. I found it generally not helpful to study topics in depth. It confused and wasted time, when all one needed is a passing acquaintance in topics.	Number	3	5	6	22	14
	Percentage	6	10	12	44	28
16. I believe that lecturers shouldn't have expected students to spend significant time studying material all knows won't be examined.	Number	3	8	16	10	13
	Percentage	6	16	32	20	26
17. I came to most classes with questions in mind that I wanted answers for.	Number	3	10	14	9	14
	Percentage	6	20	28	18	28
18. I made it a point of looking at most of the suggested readings that went with the lectures	Number	3	12	13	15	7
	Percentage	6	24	26	30	14
19. I saw no point in learning material which was not likely to be in the examination.	Number	4	8	17	15	6
	Percentage	8	16	34	30	12
20. I found that the best way to pass examinations was to try to remember answers to likely questions	Number	0	9	10	18	13
	Percentage	0	18	20	36	26
21. I now feel confident about tackling unfamiliar problems	Number	13	22	9	3	3
	Percentage	26	44	18	6	6
22. I am now confident in my ability to plan my own work	Number	21	16	9	4	0
	Percentage	42	32	18	8	0
23. I am now confident in my ability to source and use quality information	Number	24	14	9	3	0
	Percentage	48	28	18	6	0

These statistics correlate well with the QPA (2019) survey which indicated that 32% of engineering graduates felt that simply a good memory was required to do well.

While Table 4.3 records 34% of respondents indicating an exclusively deep approach, a further 34% indicated a moderate to predominantly deep approach to their pursuit of their engineering degree. Overall, 68% of graduates that participated in this study developed a mature attitude and approach towards their career. The statistics discussed above reveals a deep interest in most of the respondents to be quality engineers. This interest, however, is somewhat dampened by high workloads which often made respondents pursue more surface strategies such as rote learning, spotting and guessing likely questions. While this may seem negative, it can also be interpreted as resourcefulness and acceptance of a meritocracy that certainly extends into the workplace. Exclusively deep approaches are not always successful in practice as employees need to discern and prioritise their work and meet deadlines; it is often a delicate balance between deep understanding and simply producing results and it has to be discerned on a case by case basis.

An alarming finding is that for 10% of respondents a moderately surface approach was exhibited, while a further 8% adopted predominant to exclusively surface approaches. Overall, close to 20% of respondents have very limited motivations or deep interest in their engineering career and this is highly concerning for graduate quality.

Question 21 to 23 of Section B, shown in Table 4.4, did not form part of the SPQ and resultant score calculations. These statements were posed to invite agreement or disagreement and assess the confidence level of the graduates. High confidence levels were reported. Twenty six percent of respondents declared that they are fully confident in their ability to tackle unfamiliar problems, with 44% confident most of the time and 18% confident at least half the time. Only 12% of respondents declared their lack of confidence. Higher confidence levels were indicated regarding ability to plan their own work, with 42% being fully confident, 32% being mostly confidence and 18% being confident at least half of the time. Only 8% declared themselves mostly not confident. The higher confidence levels reported in respondents was in their ability to source and use quality information, with 48% being fully confident, 28% being mostly confident and 18% being confident at least half of the time. Only 6% declared themselves mostly unconfident.

4.5 Written Responses

Section C of the questionnaire had a particularly low response rate. While 50 respondents participated in the questionnaire and completed Section A and Section B, only 25 respondents fully completed Section C. While disappointing, this is unsurprising in light of the overall response rate of graduate participation in this questionnaire and the Graduate Opinion Survey (2019) conducted by the University's QPA department. Section C required the most writing and thought and many graduates were unwilling to forego their attention to the ceremony in order to answer this section.

Nevertheless, those who completed Section C did so very thoroughly and with great enthusiasm, providing multiple interesting points for each question. While the questions were open ended, it was possible to categorise and list common responses in Table 4.5 below.

On the question of "What were the best aspects of your degree?", the most listed response was practical and applied modules. Graduates found practical aspects, including laboratory work, workshop training and practical projects, to be the most interesting and appealing. Many students also listed specific modules of their degree programme that interested them, to be the best aspect. It is unsurprising that 16% specifically listed their final year design project to be the best aspect, considering the applied and all-encompassing nature of final-year engineering projects.

Of particular concern is that a very low percentage (6%) of respondents listed universally applicable modules such as management and business to be of high interest, yet these modules are useful in all industries while some of the highly scientific and specific modules might not be used in the workplace of most companies. However, 13% indicated that companionship with classmates, leadership and teamwork were the best aspects. Ten percent of respondents found all aspects interesting, while 16% indicated that simply the fact of learning so many new things and expanding their knowledge was the best aspect. Only one respondent commented positively on the university staff and flexibility. One respondent indicated that nothing was good about the degree.

Table 4.5: Written Responses

1. Best aspects of the Degree	No. of Respondents	Percentage
Final year design	5	16
All aspects	3	10
Companionship with classmates, leadership, teamwork	4	13
Learning new things	5	16
Practicals and applied modules	11	35
Specific modules	6	19
Universally applicable modules	2	6
Learning new software	3	10
Flexibility	1	3
Staff	1	3
Nothing	1	3
2. Aspects of the Degree most in need of improvement	**No. of Respondents**	**Percentage**
Lecturer quality of some lecturers	5	16
Work load and assessment number too high	4	13
Handling of practicals, equipment quality, low number of practicals	6	19
Tutor quality and handling of tutorials	5	16
Certain modules require improvement	4	13
Textbook access	1	3
No improvement needed	3	10
Administrative and transport issues	3	10
University environment has too many distractions	1	3
3. Expectation of daily work life and how it differs from University life	**No. of Respondents**	**Percentage**
Expect lower workload and less stress	6	19
Choose to have no expectations	5	16
Expect higher workload, stress and responsibility	6	19
Expect less guidance, more adaptability, stricter deadlines and pitching of ideas	6	19
General expectation of being very different	2	6
Expect more application and less theory/conceptualisation	6	19
More emphasis on experience and further training	2	6
Expect more peer bonding	1	3
Expect longer, set working hours but less work intensity	2	6

Table 4.5 (Continued): Written Responses

4. Reason for pursuing a degree in Engineering	No. of Respondents	Percentage
General interest in particular engineering fields	11	35
Interest in application and how things work	4	13
Wanted to be employable	2	6
Attracted to the fact that engineering is challenging and pays well	6	19
Desire to make a difference in society	3	10
Got accepted for this choice	1	3
General interest in maths and science	8	26
5. Guidance expected from Employer and expected achievements and goals	**No. of Respondents**	**Percentage**
Expect an EIT programme and to get Pr.Eng. after 5 years with guidance	19	61
Become a manager in 10 years	3	10
Want to start own business in 10 years	4	13
Further study MSc or MBA	3	10
A disposition of no expectations	6	19
Goal of fostering good relationships and having a stable income	5	16
Technical job goals (specific roles such as process engineer, project engineer, environmental engineer, sustainability)	7	23
No desire for an engineering career	1	3
6. Current employment status	**No. of Respondents**	**Percentage**
Employed as an engineer	8	26
Employed but not doing engineering work	5	16
Not employed	18	58
7. Expected monthly earnings before tax	**No. of Respondents**	**Percentage**
R10000 to R14999 p/m	8	26
R15000 to R24999 p/m	15	48
R25000 to R30000 p/m	3	10
Higher than R30000 p/m	4	13
8. General feeling about joining the workforce	**No. of Respondents**	**Percentage**
Excited and confident	14	45
Excited but nervous about level of responsibility, fear making mistakes, new environment	10	32
Not excited. Intimidated by a full time engineering job, mentally taxing and high responsibility, complexity	5	16

While practical modules were listed by most respondents as their favourite aspect of their degree, they were also the most popularly cited issue in response to the aspects of the degree most in need of improvement. Nineteen percent of respondents indicated that the handling of practical exercises, equipment quality and the number of available practical sessions was lower than they expected. While there was great interest in practical tasks, for many respondents the way the module was handled at UKZN engineering disciplines left much to be desired.

Often linked to this was the complaint regarding tutor quality. Practical and tutorial sessions are typically administered using tutors and 16% of respondents cited low tutor quality and handling of sessions as in need of improvement.

A further 16% indicated that the quality of some lecturers needs improvement, as well as certain modules, although no lecturers or modules were identified by name, nor the nature of improvement needed. Collectively though, 32% of requests for improvement by respondents were concerning lecturer and tutor quality. While comparatively few respondents mentioned this, it is also important to note that the QPA (2019) survey found that only 58% of graduates indicated that their studies were made interesting, 73% agreed that academics motivated students and 67% indicated that academic staff understood the difficulties of students.

Thirteen percent complained about the workload and the number of assessments being too high. Considering the findings of Section B, it is surprising that only 13% complained about the actual workload. However, it is important to note that the QPA (2019) survey found that only 54.5% of graduates agreed that the workload was manageable. However, 83.7% of graduates indicated that they knew the standard of work expected of them. This could possibly indicate that while the workload is high, in graduates' opinion it is understandably high. Ten percent indicated that no improvements to their engineering programme are necessary. Other low-reported issues include textbook access, administrative and transport issues and too many distractions present on university campuses, though no specifics were given of these issues.

Numerous different comments were made concerning graduates' expectations of daily work life and how it differs from that of university life. Interestingly, there were many differing opinions. Nineteen percent expect working life to entail a lower workload and less stress, while 19% expect a higher work load, greater stress and responsibility.

Nineteen percent of respondents indicated that they expect less guidance, more adaptability, stricter deadlines and pitching of ideas and 6% expect more emphasis on experience and further training, which is often the case in industry. Nineteen percent expect less emphasis on theory and conceptualisation and more application, which is concerning because this may not necessarily be the case in many companies. Six percent indicated a more descriptive perception of the workplace necessitating longer working hours but less work intensity than what they experienced during their undergraduate degree. One respondent expects more peer bonding in the workplace compared to university.

Regarding reasons for pursuing a degree in engineering, 35% merely expressed interest in particular engineering fields, while 26% had an interest in maths and science and viewed engineering as the application of maths and science. Thirteen percent of respondents had a general interest in “how things work”. Nineteen percent of respondents had pride and achievement motives indicated that they were attracted to the fact that engineering is a difficult and challenging field of expertise and pays well. A further 6% indicated that they simply wanted to be employable, which is also a prudent rationale.

Respondents indicated a variety of goals for their career and the guidance they expect from their employer. While it was mentioned that 19% of respondents expect less guidance concerning their duties, 61% of respondents nevertheless have an expectation of their employer providing guidance and training them towards getting their Pr.Eng. with ECSA within five years. Ten percent of respondents indicated that they have a goal of becoming managers in ten years. It is encouraging that while only one respondent indicated an immediate desire to start his own business, 13% of respondents expressed this desire as a ten-year goal. However, 19% indicated the curious disposition of choosing to have no expectations for their career path, further reflecting their disposition of having no expectations of their daily workplace activities as discussed above.

Interestingly, 23% of respondents had very specific technical job goals of getting into specific roles such as becoming a process engineer and project engineer and while most did not indicate a desire for sustainability when questioned about their motive for choosing to pursue an engineering career, many expressed the desire to become environmental and sustainability engineers. Typically, the respondents who expressed these very specific desires were those who have already been offered a job and were working for at least three months prior to the date of this survey. They possessed these desires because they could see these desires as attainable within their place of work.

A concerning statistic is that only 10% of respondents indicated a desire for further study, specifically into MSc and MBA studies. This is a concerning statistic for the field of engineering research.

Concerning employment, 42% of respondents indicated that they are currently employed, with 26% involved in engineering work and 16% employed, but not engaged in engineering work. While 19% of respondents expressed interest only in very specific scientific modules, only 6% expressed an interest in universally applicable modules and studies. Although 58% of respondents were not employed during the time of this survey it was revealed in literature mentioned above (ECSA, 2019) and through academic leader discussions, that most engineering graduates gain employment within six to twelve months.

Employment salary expectations have also been listed, with 26% of respondents expecting to earn between R10 000 and R15 000 per month, 48% expecting to earn R16 000 to R25 000 per month and 23% expecting to earn higher as new graduates.

Concerning the general feeling of graduates, it was encouraging to find that 45% of respondents were excited and confident about joining the workforce. Many expressed eagerness to meet new people and make new friends and work relationships. Thirty two percent of respondents indicated that they were excited but also nervous about the level of responsibility they might be expected to shoulder; they were afraid of making mistakes as they were aware of the high impact engineers can potentially have on others. Some had simply a general apprehension of being in a new environment and were eager to get over that phase. Of high concern was that 16% of respondents indicated that they were not excited but rather intimidated by a full- time engineering job and all the complexity and responsibility that comes with it, which could be mentally taxing.

4.6 Interview Responses

As mentioned in Chapter 3, Section 3.9, interviews were conducted with four personnel whose profiles are described in Table 3.3. Interview duration varied according to the responses of respondents. In order to maintain anonymity of respondents, they have each been referred as Respondent R1, R2, R3 and R4, where R1 represented the Agricultural and Civil Engineering context, R2 the Chemical Engineering context, R3 the Mechanical Engineering context and R4 the Electrical, Electronic and Computer Engineering context respectively. Respondents were first asked to briefly describe their position before beginning their formal interview. The interviews were conducted in a semi-structured manner with follow-up questions and redundancies being overcome. The schedule of questions for the interview is available in Appendix D.

4.6.1 Employment and Work Expectations of Graduates

In this theme, respondents were asked about the employment and daily work expectations of engineering graduates from UKZN. A variety of responses occurred. In the civil and agricultural engineering context, graduates were said to expect a short learning and development phase of a few months and be involved in small calculations and checks and this is a justified expectation that closely matches reality.

R1: "Graduates would be expected to be going through a learning curve during their first couple of months at any organisation in the industry."

Chemical engineering graduates were stated to expect high involvement with complex projects and progressive work. An expectation of commanding a high salary was also mentioned. These expectations, however, are increasingly unjustified as many small companies are engaged in maintenance rather than frontier projects. It was also the feeling of R2 that graduates are not sufficiently aware of the amount of further training they will undergo in their first two to three years.

R2: "…they feel that they're gonna be walking directly into some sort of design house"; "To a greater extent I think they are also thinking that they are going to be combining commanding a lot bigger salaries than they actually get."

In the mechanical engineering context, graduates were said to be expecting a structured graduate training programme including more practical skills, which is largely justified with large firms but with smaller firms training is much less structured and formal.

R3: "Look, the expectations is that a new graduate goes on to graduate training programme and they learn the fundamental skills required for mechanical engineering and these are generally associated with workshops."

Respondent R4 revealed a much simpler angle to the question. Ultimately graduates just want a job and job security. Many are pressured by family responsibilities. Among disciplines, there is variation. Electrical engineering graduates have an expectation of doing what they learned and having an electrical engineering job, whereas electronic and computer engineering graduates are typically more open to anything, including jobs in the banking sector. Some are also immediately thinking of starting their own software company. R4 expressed great inspiration for being part of making these graduates employable and to see them employed and lifted out of poverty:

R4: "And the impact of taking an African student from a township environment and putting him through this process of converting into an engineer has amazing knock-on effect, not just to him and his family but supporting structure back home. So there's a sense of personal social fulfilment that I get."

4.6.2 Employer Expectations of New Graduates

In this theme, respondents were questioned generally about employers' expectations of new graduates. The context was immediately understood to be in terms of graduate competence. Employers were stated to expect a high learning attitude and basic general engineering skills from their new graduate employees. Respondents also generally stated that employers have mostly accepted that their new employees will have to undergo further training. Discussions shifted as well to compare the context of small companies and large companies and how their expectations differ.

R3: "Yeah I think it's proficiency and it's proficiency in the skills of maths, science, physics and essentially problem solving because most engineering is problem solving; there's a problem that needs to be solved and therefore you need a solution."

R4: "I think they probably see our graduates as very versatile, very knowledgeable skilled person but still needs to be professionalized and directed in whatever the company business is."

R2 interestingly indicated that smaller companies that are employing their first engineers are often unaware of what their capabilities are and often have high expectations of their ability. Such engineers face an enormous amount of stress from the beginning but in the long term become irreplaceable assets to the operations of that company. Larger companies, however, have a structure and lower expectations of new graduates, but this can often be of detriment to the new employee because it leads to complacency and the employee struggles to become an asset to the company above his peers.

R2: "You'll find that those junior engineers are actually expected to work or perform at a level much higher than those individuals that are in a structured engineer in training programme."

Concerning trends with new graduate intakes over time, R1 did not report any negative trends and expressed that employers have given good feedback in their internal surveys conducted uniquely by Civil engineering. However, R2 expressed that the trend is negative in terms of the number of high-performing engineers and this was seen as systematic. Students from high school are relatively of poorer academic quality than a decade ago and they go through university and although they become satisfactory graduate engineers, the number of outstanding or potentially impactful graduates has declined.

R2: "...you'll find maybe a cohort of 20 engineers and maybe two of those engineers are of the same calibre as what we were seeing a lot more maybe a decade ago and then the other 18 engineers out there working satisfactorily but not making that same impact as before."

However, R2 also stated that it seems that international employers' perceptions of South African engineers has improved over the years, largely due to government initiatives. Technical communication has also marginally improved in the Chemical Engineering context.

Conversely, R3 expressed that in the mechanical engineering context technical report writing has been reported by employers to have declined in quality and R3 has postulated that this may be due to many new graduates not being sufficiently proficient in English as they are not English-first-language speakers, while on a positive note teamwork ability has markedly improved in new graduates due to the presence of numerous group projects. There has also been a trend for employers to expect more software and controls skills from mechanical engineers. Increasingly, mechatronics rather than pure mechanical engineering is being required from employers. R4 revealed that gaps in knowledge have often come up over time, where graduates have outstanding ability in certain high-end tasks but often lack a practical understanding of how simple things works.

R4: "So you might have a student that's highly mathematically skilled. Okay. And can solve for you Fourier transforms and can do big coms type calculations and understand how the future cell phone mobile networks are going to be operating. But then at the same time they don't know how the earth, on a distributor board at home, works. They don't know what is Earth, what is live, which the neutral sort of thing."

This was attributed to a number of undergraduates coming in without much engineering background in terms of social capital and general flare for opening things up and seeing how they work.

4.6.3 Mismatches between Engineering Curricula and Industry Needs

The question of surveys indicating that there is a mismatch between undergraduate curricula and the needs of industry received highly impassioned responses from all respondents. All respondents attested to having dealt with this accusation on a never-ending basis from various industry players. All respondents considered such assessments unfair and unreasonable.

R2: "I think it's a little bit of an unfair assessment to be honest right to say that we aren't addressing the needs of industry."

R3: "The thing is we're a broad-based degree. We produce a mechanical engineer with a broad base of skills."

R4: "Haha, honestly I've no time for that because, I'll tell you why. It actually frustrates me because there'll be someone in industry wanting X, another one y, another one p. There is no way we can we can cope with the different demands."

The general response is that it is an unfair assessment and expectation that various industry employers constantly want graduates to be taught skills and subject matter that suits their particular business. R2 discussed that the mismatch is prevalent when looking at the context of the 4th Industrial Revolution (4IR) and not only at universities; nationwide it has been a challenge and South Africa is perceived to be lagging behind in these advances. On the other hand, there is very limited room for change as much of the subject matter in engineering curricula is fundamental engineering knowledge that engineers in their respective disciplines absolutely need to know and be proficient in.

R2: "It's a big balancing act that because you can't really remove that material."

Advice provided was to contextualise current modules to 4IR aspects or introduce technical electives.

R1 had an interesting point of view that the mismatch will always be there and it is the educators' job to minimise it, but there are even cases where a mismatch is more desirable. R1 gave an example of Pavement Design where UKZN teaches the current world state of the art but such techniques are not practiced by South African construction companies yet. Many industry players advise that old techniques be taught to suit their current operations but this is not in the interest of the graduate.

R1: "Okay so this mismatch would be there all the time which is from my side I think it's a positive thing. It's not (necessarily) a negative thing."

4.6.4 Postgraduate Qualification

On the theme of postgraduate qualification and its impact on employment attractiveness, all respondents expressed that postgraduate qualifications in engineering did not typically increase employment attractiveness for new graduates or command higher salaries. There are exceptions, but generally postgraduate studies increased the graduate's knowledge and skill as a researcher, which would be attractive later on in their career, or in innovation-driven companies which are not very many in South Africa.

R1: "...postgrad qualifications will not increase their employment opportunities but it will increase their knowledge definitely and we will make them more competitive in terms of what they know but at the end of the day generally speaking that the market is not encouraging postgraduate studies."

R2: "But it's happened on many occasions that the students have actually come in decided to do a postgraduate degree, master's degree specifically and then use that as a sort of like a springboard and have been able to secure not only employment but really good employment."

R2 explained that it is not automatic that MSc and higher qualifications make one more attractive as an employee or command higher salaries, but rather it depends on the skills learned and the marketing of those skills when in a job interview. This was also elaborated on by R3. Unfortunately with most companies in South Africa and with the current economic climate, operations are largely maintenance-driven rather than innovation-driven.

R3: "So a lot of industries are seeing the benefit of that, that if a person has done a postgraduate degree like a master's degree, they then have developed the skill of research, therefore that's good a researcher and of course it's an attraction for them because when you're trying to solve a problem, you spend time researching what the problem is. You research the solution." ; "You see if a student isn't exposed to innovation, he might himself never developed that skill which he may have that skill and creativity you may not develop you might do a little bit in his undergrad degree but he won't develop further because he'll go to a maintenance company and just end up doing maintenance."

R4 expressed that postgraduate studies are attractive mainly to engineering hobbyists rather than most of his cohorts who are happy to be employed and do a variety of tasks that are even not necessarily pure engineering. This is true especially for electronic and computer engineers who often end up in banking and insurance sectors. Interest in postgraduate studies is in decline mainly because pure interest in engineering is in decline, with the majority of graduates seeing engineering as an occupation to earn well and get out of poverty and this can potentially impact graduate quality.

R4: "…because I think we are managing to still be making and producing competent engineers to solve problems. You don't seem to have those geeks. If there are they just end up doing masters and PhD and staying in the system."

There are a handful of professionals who, after years of work, express interest in postgraduate studies. However, for some engineering qualifications it can be practically impossible to pursue this on a part time basis because of their job demands. R1 indicated that this is a problem, in particular with civil engineers, due to erratic work hours.

R1: "…especially the civil and sometimes they work after hours basically because they need to close a road after hours or so in general it's not really an attractiveness for employees."

4.6.5 EIT Programme Availability, Structure and Assessment

On the theme of EIT and graduate training programmes, R1 indicated EIT programmes were non-existent in civil engineering. Training of civil engineering graduates is in the form of informal mentorships of varying quality. Graduates are expected to register as Candidate Engineers with ECSA immediately and put in their own effort towards Professional Engineering Registration. With other engineering professions however, the presence of a graduate training programme varied. For chemical, mechanical, electrical, electronic and computer engineering, respondents indicated that large companies have EIT programmes which typically last two years and rotate new employees through different projects and departments.

R3: "The big corporations have structure, like Eskom, Transnet and mining companies. And the reason why is because these industries are very specific to what their needs are."

EIT programmes are typically tailor-made to suit a company's operations and that is a primary motive for the programme. Smaller companies, however, do not have the budget for these programmes and training is typically in the form of informal mentorship. R4 expressed that EIT programmes are available for electrical engineers more than for electronic or computer engineers and the main reason for this is safety.

R4: "I would say the Electrical guys are very focused on engineering and service training"; "I think it's because you've got more and more chance of dying in electrical engineering than electronic or computer."

Regarding the typical structure of EIT programmes, respondents were generally vague in their responses, with the claim that the programmes are highly specific. R2 was the only respondent who seemed reasonably aware of what EIT programmes entail and directed the study towards an ECSA document which gives key guidelines for EIT programmes for chemical engineers (ECSA, 2013a). The details of the structure is discussed in Section 5.7.

Concerning assessment in graduate training and EIT programmes, all respondents indicated that performance deliverables were typically of the format of a technical report as well as presentations. However, some differed on the frequency of report writing and presentations. Reports and presentations could be weekly for chemical engineers in certain companies, while big mechanical engineering employers require reports every three to six months. Report writing most often takes precedence, while presentations are also used by departments to illustrate their activities and achievements to upper management. Some new graduate employees may report to one manager or several. The strictness of report and presentation assessment were also stated to be quite severe.

R1: "And the exit level outcomes. Because basically they expect engineers to be able to apply for professional engineering registration within three to five years."

R2: "And typically what happens in these presentations is they'll ask you questions until you can't answer it. And yeah. I mean you'll hear the stories like the rumours about graduates come out of these presentations and they start crying and things like that and it's you know really, that's work."

R3: "Companies are centred on report. The graduate in training has to do report every three months or every six months. And these of course are then evaluated by their mentors and their supervisor. The Engineering Council of South Africa also monitors this"; "Some companies like it that they showed the other managers and to the CEOs what they're doing."

R4: "It's got this report writing aspects of a project for them to take. Control of, drawing up specifications for certain projects and then it's probably outsourcing a lot of it, managing it, signing it off and then being checked by their supervisor."

R4 also discussed an alternative situation particularly with electronic and computer engineers where some are employed directly for what they know and can do and their success is monitored based on the success of their task.

R4: "I know CEOs are driving up to the airport to meet a graduate and is about to fly to Joburg, offer him a job because he knows he can solve a certain problem for him that he's got back at work and offer him a job right there. So yeah it's um. Just it's sort of new interventions and all that."

4.6.6 ECSA ELOs and Attributes

In this theme, respondents were reminded of the 11 ECSA ELOs and asked whether employers reported new graduates to be lacking in any of them. Respondents did not indicate that anything was seriously lacking, but did report that certain ELOs were repeatedly stated by IABs to be crucial, such as problem solving and application of scientific and engineering knowledge. This aligns well with graduate expectations and QPA (2019) indicated that 96% of graduates agreed that their degree sharpened their analytical skills and 94% indicated that it sharpened their problem-solving skills.

Often the conversation on ELOs surrounds how the ELOs are assessed by the university, with recent examples being that of engineering management which is a recently added ELO. R4 indicated that the binary nature of ELOs is highly welcomed by industry as certain assessments might be passable due to marking structures, but not meet ELOs which translate to key areas that the graduate must get right. In such cases, the module must be repeated.

R4: "Okay but if you look at the students you talk to them you know and this guy should not be able to pass Design but on paper according to this structure they have. But we talked to them and offer them certain criteria connected to that ELO. Then you realize that this guy cannot solve a problem properly therefore Failed ELO So I think in that perspective I sort of appreciate that ELO system."

Respondents were far more direct when listing which ECSA attributes graduates were found to be lacking in, according to industry. Independent and lifelong learning skills were the most commonly mentioned attributes thought lacking. Many new graduates were found to have an attitude that their learning is now complete and if they fail at tasks at work, they would generously get more chances.

R1: "Independent learning and lifelong learning skills. Social skills. That's another one. Yeah. These are the two."; "Lacking of self-motivation created by the educational system. Because a lot of students the work towards no goals and they arrive at results. And they have more than one chance every time. So they are. So relaxed. And uh if they are not under pressure they will not be self-motivated."

R3: "Not specifically lacking but I think attitude is one which is brought up is that the graduates think that once you've got your degree will then the job is done. But in fact you start working harder and harder. And I think it is the expectation from the student that you know you can free wheel."

R2 stated that such attitudes cannot be observed until a new graduate is observed working on the job.

R2: "Individual lifelong learning skill and attitude that can only come through once the person is employed and then you see them working on the job. The distinction is actually quite clear that in terms of the individual when you go into organizations and you see these individuals you'll see them that are working on the same level but you'll see one individual that really goes the extra mile in terms of wanting to understand the problem in its entirety."

Social skills and technical communication were also highlighted, in particular language barriers and confidence. Non-English-first-language speakers in particular lack confidence and speak minimally in their presentations and need to be prodded for more information. On the other hand, graduates who are only fluent in English struggle to converse and connect with many labourers who do not speak English well.

R4: "What I've picked up while examining our design students those guys are back to go into the workforce. Okay. What I hear is being confident can be a problem. Often I, Here is a case of once we've got him talking. I think that understood the work they did but not the intensity with what they actually manage to explain articulate. But he had to draw it out."

R1: "The problem is we have a lot of labour who don't speak any language other than their mother tongue. And the engineers cannot speak that specific language or languages. So the lack of communication creates some social silos inside the organizations and you can see that at any level. And we still find that people are more or less in social silos Because of the diversity."

A further observation of all new graduates was their lack of ability to appeal to different types of audiences. They do not know the difference between how to speak simply to a colloquial audience as opposed to being more practical and precise towards a professional audience.

R4: "So for example there's a massive difference between a colloquial type audience versus a professional audience, which is you might be boring the hell out of a professional audience because he's talking so fundamental that you don't just cut to the chase."

4.6.7 Further Training and Upskilling Courses

The question of what courses or workshops are available often became redundant during interviews as they were asked as follow up questions to others. R1 indicated that SAICE often advertised courses and workshops in different provinces. R2 indicated a drive for more online courses rather than physical ones. R3 and R4 mentioned institution seminars which are often free to members who subscribe. Many of the courses are either highly specific such as software courses or very general such as labour law or management courses. There was no direct indication however regarding the name or content of such courses.

None of the respondents could definitively answer the question pertaining to how much is spent on training new graduate employees over a five-year period. It was explained that this question was ideally suited for actual employers, nevertheless they did offer some insight. R2 indicated that short courses for continuous professional development (CPD) could cost R35 000 to R50 000 for just three to five days. Some companies have developed their own training programmes where educators and facilitators are sourced from the company to train others, with the cost effectively becoming an opportunity cost of hiring the employee to facilitate courses as opposed to being involved in the company's productive operations.

R2: "A lot of companies do that like for instance SAPREF they get training programs that are accredited by Shell. So they don't really pay for it. But somehow there's a cost involved there, because your facilitator is being seconded from somewhere else in the organization to actually do that. Someone is being paid to fill this position while he's doing this."

R4 indicated that in some cases, government funding instruments have been set up and used for smaller companies to apply for the purpose of upskilling new staff. Some seminars were also free to access if staff are subscribed to various engineering institutes and pay an annual fee.

4.6.8 Skills and Knowledge Gaps and Overemphasis

This theme encompasses any aspects of engineering skill and knowledge that contemporary industry found to be either inadequately instilled or overemphasised. Concerning skills and knowledge gaps that industry feels were not adequately instilled, respondents were generally of the opinion that these were often skills that were unfair to expect the university to teach as they are too specific. R1 indicated that many companies want proficiency in very specific software that they use, a point which R4 also made. R2 indicated knowledge of batch processing, which is a niche chemical engineering process that is easily picked up. On the extreme end, R3 indicated a constant effort by some companies to advise change to an entire curriculum to suit their operations.

R1: "Mainly software. Industry would expect the engineer to know the software they are using at the company and that that's not the case and it shouldn't (be)."

R2: "Maybe in terms of batch process. Batch processing is something very niche you will find it in a certain number of industry is maybe you know the pharmaceuticals or processing of alcohol or something like that."

R3: "We have had (Company X) come and want us to change our whole curriculum. Of course we resisted it. It's impossible. We can't become a training ground for (Company X). We do have from time to time (Company Y), have tried it as well, tried to get us to change curriculum just to suit (Company Y) people but we can't because then we'd become a University of (Company Y)."

R4: "…we might get your odd demand but I actually think a lot of what Industry out there accepts that we can't produce an engineer for every job out there. Yeah. So they do realize that engineers are these empty viable vessels that can be directed and honed very quickly."

R3 indicated that a common complaint from industry was graduates' lack of environmental and even socio-economic awareness, as they are often highly focussed on pure science and engineering aspects of work.

R3: "I think the socio economic aspect as well most engineers are not well aware of all that depth the socio economic aspect of what you do out there impacts the community. They're just building a bridge or whatever. Environmental impact as well. Students often aren't aware of *that. They just want to build something in that they don't realize that the impact on the environment is important but they're becoming more real."*

In terms of deliverables, a consistent complaint from industry according to R3, is in the area of report writing. Part of this is linked to the fact that many students are not English-first-language speakers but it is also linked to surface strategies of students in trying to get around having to work on a technical report by themselves. Even in individual reporting, they are getting help and working together to get the assessment completed in time.

R3: "Students come out of the school system I think without, or are not as proficient in ability to write reports and communicate well with technical report writing. They go through the university system and they dodge it in maybe, (such as in) their practicals and their assignments you know they're getting help from each other etc. etc., there's a lot of help going on. Often the student is supposed to do things on their own but they're getting help and then they don't develop that proficiency in terms of technical report writing and that's probably the biggest complaint we have from industry."

Regarding over-emphasis of any skills or knowledge, respondents had varying opinions, but were equally lacking in conviction. R1 felt that contracts, management and labour relations seem to be overemphasised but stated that they do need it anyway for ECSA ELO requirements. R2 indicated an over-emphasis on certain software (Aspen) not found in many companies. R3 indicated that the engineering industry complained about overemphasis of mathematics, yet many graduates end up in the banking sector where mathematics is highly valued. While employment in non-engineering roles is not seen as ideal, R3 is of the view that any employment is better than no employment and engineers are no less useful in other industries than they are in engineering industries.

R3: "…we feel that engineers that we're producing are very broad and they're well-rounded and they are quite generic which means they can go anywhere like to the banking industry or insurance, because you know some people can't find employment. So limiting a person's employment by cutting out stuff that could have been useful in the bank or insurance would be a bit unfair. I know we don't really want to produce people for banking but it is what it is. Unemployment is high in our country and people can go that way."

R4 has expressed that they are not overdoing anything and stated that it is important to be very wary of making any drastic changes to the curriculum based on certain opinions of overemphasis.

R4: "I hate to take out anything, the system has taken years to evolve. You take out one course you put another course and what you realize is that in two-years' time there's a lot of things like "Oh my God you left quantum mechanics and now we try to teach these guys the physics of electronics and you take our quantum mechanics course". Yeah I don't think we're overdoing anything."

4.6.9 Company Participation in UKZN Engineering Programmes

All engineering disciplines were found to receive input from a high number of key industry partners. Civil and Agricultural engineering received feedback and input from Ethekwini Municipality, SANRAL, SAICE and Hatch. Chemical engineering received input from Sasol, SAPREF, Engen, Umgeni Water, Mondi and Sappi. Defy, Bell Equipment, Transnet and Eskom advised Mechanical engineering. Electrical, Electronic and Computer Engineering are advised by Eskom, Transnet and various smaller IT firms.

4.6.10 Employer Teaching and Learning Advice

Regarding teaching and learning practices and policies, all respondents indicated no industry interest or involvement in the way teaching and learning occurs, mainly because they are out of touch with this matter. R2 indicated that the only criticism that they used to get a few years ago was regarding the provision of PC and internet access, which he believed has been resolved. Statistically however, only 62% of graduates felt that these facilities were sufficient (QPA, 2019). Industry requests, however, are typically around evolving subject matter, including new or old themes that are becoming relevant, such as changing between having a course in nuclear energy, to having a course in renewable energy, or incorporating it into existing modules as case studies. R3 indicated some pressure from government to gear the curriculum to address the changing demographics of the country's engineering cohorts.

R3: "…there is pressure of curriculum development and change just due to the demographics of the country. And that's coming more from government than from industry and maybe governments are also responding to industry in industrial relations. It's that we do curriculum *development and we look at where we structure the courses more closely to what the industry needs so that pressure's coming in government."*

4.6.11 Suggestions on Bridging the Gaps

This theme was treated as an open-ended discussion requesting advice from the respondents for UKZN decision-makers regarding bridging the gaps between graduate and industry expectations to ensure progress. A variety of responses emerged. R1 emphasised better usage of advisory boards to play a more active role in curriculum development and that UKZN should adopt a more standardised approach to advisory-board engagement.

R1: "I think the advisory board is a good thing. However we are not taking it very well. We are not getting to the optimum out of that. We are not getting the optimum from advisory board….I think looking at the curriculum is one important thing. Involvement of an industry in the assessment of ECSA exit level outcomes is very, very important."

Currently, the process is highly informal and dependent on the motivation of discipline personnel.

R1: "Basically the only responsibility they had was to resolve the board. So we changed that to make it more of the department's responsibility to make it more active. Dynamic. But again it's very much dependent on people themselves. There it is nothing structural even at the school level to ensure that we have a very active advisory."

R2, R3 and R4 suggested deeper ties with industry and more encouragement for industry to provide vocational training. All three respondents pointed out that it is increasingly difficult for undergraduates to get engineering industry experience and compulsory vacation work and this has impacted on their quality as practical engineers. All undergraduate engineers are required to complete at least 12 weeks of vacation work, preferably in an industrial environment. However, with lack of offers of vacation work from industry, undergraduates rely on lecturers to give them small laboratory and modelling projects which does not necessarily achieve a conventional work experience, or give them confidence in the workplace.

R2: "There has to be a structured framework for this store, right. Maybe something that I'm working on in the meantime is to get some sort of a structured framework together to connect these students with the employers but to give the employers suitable resources to take on these students." ; "a student can come in from matric, do their four years without any engagement *with industry and then somehow manage to get some vacation work with lecturers here, do their full 12 weeks, do the workshop training and then go to industry and then "Oh my gosh what have I done. This is not for me"."*

R3: "The next thing is I think students they lack practical experience. They only do 12 weeks in-service training. So most of them go into industry without even using a spanner or a screwdriver ever. So they're very reluctant to get their hands dirty and that's a pity because mechanical engineering is a science of machines, if you can define mechanical it's a science of machines. But a lot of students don't know how the machines work which is a pity." ; "You know you always try and get companies to take on a student by running a guilt trip on them and say "listen you owe it to the country to help train them". Yeah but well a lot of companies say they just don't have the time and the money."

R4: "I think historically it's always been difficult to get all graduates vac work. On the other hand, I heard some really good things, feedback saying "Wow those four vac students that came to us. You know we basically gave them money for transport, a little bit extra money for lunch and stuff but they were worth ten times what we paid them"."

Other minor advice included introducing an English language course to improve technical reporting, especially by non-English-first-language speakers. R3 suggested extending the degree from four to five years but has admitted this would be highly controversial.

4.6.12 Open-Ended Discussion and Final Words

The final question of the interview simply requested any final words concerning this topic, which aimed to introduce some inductive thematic analysis into the study. When asked if there was anything else they would like to add, respondents had a variety of responses once again. R1 had nothing further to add. R2 touched once again on the 4th Industrial Revolution and its impact for engineers and engineering employment.

R2: "You know we are in this transitional period now. We know people are realizing that this fall out that it's really not something that's completely out of our control. Many people would like you to believe that it really depends on how much we want to embrace it. It's not something that's going to lead to some complete destruction of human workforce or anything like that."

R3 pointed towards the convergence of engineering and that it would be a considerable challenge to give engineering graduates the great exposure that engineers in more developed countries are privileged with and that places them on a 'back foot'. Moreover, opinion was that most South African companies are maintenance-driven rather than innovation-driven. R3 also raised the issue of how UKZN and South African universities produce engineers compared to how other international universities operate. It would be worthwhile to research whether teaching and learning practices and curriculum designs at UKZN are still in line with contemporary methods at tertiary institutions internationally.

R3: "…but I think engineering is converging, to almost a single unit because as I said engineering is multidisciplinary."

"In the international community, where does South Africa fit in? Are we keeping up to the way engineers are being produced, outside compared to what we produce? You know we are accredited through the Washington accord which we accept. But I think that because of the industry we have here compared to what they have in Western Europe, the US and China and Japan our students are a little bit disadvantaged, they can't be exposed to that high tech.

"Go to Google or go to Space X. You know you can just imagine the kind of training areas they see there, whereas our guys go to Transnet, Eskom, which are very straightforward companies which are very maintenance driven companies. Space X and NASA, these are very research innovation driven. So I think that yes it's a pity that being on the tip of Africa we are a little bit isolated, not only in terms of our ability to collaborate and interact but also students possibly aren't being exposed to the real high tech."

R3 further mentioned that exchange programmes are also not as active or well-funded as they used to be. R4 expressed concern about many graduates' intentions to pursue an engineering career and went on to explain that there are not many engineering enthusiasts around. While the intention is understandable and R4 expressed great admiration for people (who still become satisfactory engineers) trying to get out of poverty, he lamented the lack of pure engineering enthusiasm.

R4: "What I do worry about is that they do engineering for the pay cheque, they've been coming for the pay cheque. A lot of the time that is the case. Yeah I'll go to graduate and he will be a BMW waiting for them and a couple years or two."

R4: "I don't find that we have those. There are some students like that. But look the majority sees engineering as a way out of a problem socially economically. And if you have that attitude *you know maybe not going to be the most competent engineer in a way. We try to change it. I know I do try."*

The QPA (2019) survey, however, indicated that only 61.3% of graduates agreed that studies were made interesting, indicating that there is also room for improvement in encouraging interest and enthusiasm at undergraduate level.

4.7 Conclusion

All results pertaining to this study have been presented in this chapter. Demographics and job factor statistics were presented in tabulated form, with key results highlighted as text. Section B results of the graduate questionnaire were presented as a tabulated summary of approach statistics, as well as statistical results of responses to each question, with key responses highlighted in text. While written responses were open-ended, it was possible to categorise and statistically report responses as there was a limited number of types of responses. Results were thus tabulated as descriptive statistics and key findings were highlighted. Interview responses were completely qualitative and each deductive theme was presented in summary or including direct quotes where appropriate. A few minor themes were inductively ascertained towards the end of each interview. The chapter thus accomplishes the first two objectives of this study mentioned in Section 1.6, namely to determine the employment and daily work expectations of newly engineering graduates and to ascertain the expectations of engineering employers concerning new graduates. The next chapter brings graduates' and academic leaders' responses together to assess any prevailing alignment or mis-alignment and draw links between study findings and previous research.

CHAPTER 5: DISCUSSION

5.1 Introduction

Chapter 3 presented the research methodology and Chapter 4 presented the complete results in this study. Results were tabulated and key findings highlighted in text in an impartial manner. Qualitative interview responses were also presented through direct quotes and combined reporting in text, impartially without assumption or discussion.

This chapter begins firstly by discussing observations associated with research methodology, in particular the graduate response rate during the graduate survey. Results are thereafter examined holistically and comparatively in order to assess the alignment of graduate and employer expectations with each other and with prevailing reality. A number of key areas of alignment and mis-alignment are ascertained and the causes articulated and explored. These include graduate hopes for growth opportunities and how these align with the field of study, the issue of workload and graduate depth, expectations of application and less conceptualisation, the expectation of structured guidance and salary expectations. Graduate reasons for pursuing engineering are discussed, followed by a discussion on assessment mismatches between undergraduate study and the workplace. The costs of further training and lack of interest in postgraduate study is also discussed. Other mismatches and mis-alignments are then discussed, beginning with a note that a mismatch can often be a natural and even positive occurrence. Language barriers, lack of engineering background and confidence mis-alignments are discussed, followed by issues of ELO's, ECSA attributes and industry participation. Lastly, the chapter discusses the responses received in this study, in light of the theoretical frameworks presented in Chapter 2.

5.2 Graduate Response Rate and Sampling Approach

As mentioned in Section 4.2, the graduate survey achieved a response rate of 42%. Likely reasons for the low response rate may be the length of the questionnaire, as well as the fact that in addition to the questionnaire developed for this study the university QPA department issues its own questionnaire to each graduate during the ceremony (QPA, 2019). Also, as the respondents were graduates attending their own graduation, it is possible that participation in the written segment was seen as time consuming as graduates were excited and keen to be attentive to the actual event and not be distracted with providing lengthy answers. Despite the above concerns, the response rate was not abnormally low for this particular survey setting. By comparison, the University QPA questionnaire (QPA, 2019) was handed out to 393 graduates of BSc. degrees in engineering, yet only 221 graduates (56.2%) responded.

This convenience sampling method offered the advantage of surveying graduates from all engineering disciplines at one sitting, thereby achieving stratified probabilistic sampling. However, the nature of the ceremony – a once-in-a-lifetime graduation event for many – discouraged participation in anything but attentiveness to the actual ceremony. Response rates were thus naturally not high. Nevertheless, the graduation ceremony provides the only opportunity to survey so many graduates in a single sitting, as no other opportunity for graduates to congregate exists. An alternative would have been to approach graduates individually through personal contact, which would have been difficult and time consuming. Another alternative was to survey final-year students while they were still attending classes, but data cannot be guaranteed to be the same as the surveying of actual graduates.

5.3 Growth Opportunities in a Company

R4 revealed that there is an industry perception that most graduates simply expect or want to have a job and be employable and this was cited as a concern that might impact graduate quality. Under the Biggs (2001) framework, this attitude translates into a surface motive. The graduate survey in Table 4.3 on the other hand indicated 68% of graduates had moderately to exclusively deep approaches to their engineering career. Table 4.2 showed that 64% wanted growth opportunities in the company they are employed in as first or second priority. Table 4.5 showed that 61% of respondents possessed intrinsic interest in science, technology, engineering and mathematics.

It is possible that employers are underestimating the mature and prudent drive of new graduates to grow in their career and these assumptions may negatively impact on how new graduates are treated, thereby stifling innovation and new ideas. R3 expressed that employers like graduates with all the broad necessary skills in order to condition them into their particular enterprise which is often a maintenance-driven enterprise and this conflict between employer and graduate aspirations may impact negatively on the long-term drive, innovativeness and productivity of these new employees. The expectation of innovation and reality of maintenance further alludes to the picture discussed in Section 5.13 below concerning engineering postgraduate study.

5.4 Alignment to Field of Study

Twenty seven percent of graduates in Table 4.2 indicated that they desire strong alignment to their field of study. Table 4.5 suggested low interest (6%) in universally applicable modules, 19% were interested in very specific modules and 23% of respondents in Table 4.5 had very specific job goals. This finding agreed with the study of Feutz and Zinser (2011) which found that graduates appreciate programmes that are specific.

Academic leader responses, however, have suggested that this has become an increasingly unrealistic desire for graduates of a Bachelor of Science in engineering due to the versatility required by growing companies in the 4^{th} industrial revolution. R3 and R4 pointed to the large number of engineers who find employment in banks and insurance companies. In the graduate survey itself, of those who have indicated that they are already employed, 16% indicated that they are not doing engineering work. Fletcher et al. (2017) also surveyed respondents who worked as engineers in engineering companies and found that technical skills were often low on the agenda, while general transferrable skills such as reporting, communication, teamwork and business acumen were more highly valued and yet lacking in many new graduates.

On the positive side, Table 4.4 indicated that graduates do have a spark of interest, even if they may not have been explicit about it. For 68% of respondents, it was either 'always' or 'frequently true' that any topic could be interesting once they get into it. A further 22% indicated this to be true at least half of the time. In addition to this, 36% of respondents agreed that it was 'mostly' to 'always true' that studying academic topics could be as exciting as reading a good novel or watching a movie, with another 36% indicating this to be true half of the time. This is a highly positive indication as it reveals that graduates were not simply interested in a few topics of their degree while shunning the rest, but rather possessed an appreciation for all aspects of their degree in general. It is interesting that only 44% of respondents spent significant extra time trying to find out more on relevant topics. While interest is clearly indicated, fewer respondents put effort into pursuing such interests. This is possibly due to the high work load of engineering degrees.

5.5 The Issue of Workload and Graduate depth

The Study Process Questionnaire (SPQ) was designed to cross examine responses and responses to questions posed in the negative were generally consistent with responses to questions asked in the positive. Statement 15 of Table 4.4 for example, which read: "I found it generally not helpful to study topics in depth. It confused and wasted time, when all one needed is a passing acquaintance with topics", was met with stark disagreement, with 28% stating this to never be true, 44% mostly untrue and 12% true only half the time. Yet, when questioned regarding effort in statement 14, which read: "I spent a lot of my free time finding out more about interesting topics which were discussed in different classes", this was met with the general disagreement of 50% of the respondents, with only 22% pursuing this half of the time. Similarly, most respondents did not look at suggested readings and largely disagreed with statement 18 which read: "I made it a point of looking at most of the suggested readings that went with the lectures". Again, student motivations were rich and deep but comparatively fewer students actually put effort into it.

Section B of the graduate survey revealed an important gap between graduates' motivations and their actions or behaviour. While deep motivations are present, the sheer workload of undergraduate engineering degrees often results in an embrace of surface strategies, where students are studying the bare minimum to keep afloat and pass their modules. There is very little room to nurture these deep motivations into deep action and it has somewhat impacted their capacity for mature expectations of the workplace. The QPA (2019) Graduate Opinion Survey found that only 53% of engineering graduates felt that there was sufficient time to understand content and only 54.5% indicated that the workload was manageable, which are the lowest statistics in the entire College of Agriculture, Engineering and Science.

An interesting point was that on question three of the written responses (Table 4.5), concerning graduates' expectations of the workplace, the question was interpreted by 44% of respondents to concern workloads. Nineteen percent of respondents expect a lower workload and less stress compared to the engineering degree they studied for. A further 6% expected longer work hours but less work intensity and stress. Nineteen percent expected higher workloads and stress and a further 19% expected less guidance and stricter deadlines.

According to academic leader responses, workloads and stress will increase in many companies. R2 indicated that some companies can require presentation of results as often as once a week and smaller firms typically have higher expectations than larger firms. The expectation of some graduates of less workload and stress can unfortunately be an invalid one. Graduates were divided in their expectation of the workplace in terms of workload and anxiety, with a further 16% of respondents having no opinion on this. The QPA (2019) survey also revealed equally polarised opinion regarding the manageability of the workload. This complete contradiction and equal split of opinion indicates a need for educators at the undergraduate level to seek clarity and liaise with industry in order to derive the correct perception and to prepare graduates psychologically for the workplace. Educators perhaps need to ask, "Can both expectations be correct or is only one definitive correct in a general sense?". Many respondents seemed to be highly unsure of this particular question. Six percent indicated a general expectation of being very different, while 16% chose to adopt a position of having no expectations. Educators need to ask, "Could this attitude of no expectations or simply general difference perhaps be the most prudent stance?"

Itani and Srour (2016) further found that as a result of the workload and generally low aspirations of many undergraduates to simply be employable, certain modules begin to be more emphasised while others are neglected, at least in undergraduates' minds. Technical modules are highly emphasised while modules concerning soft skills like presentations and technical report writing, which are highly valued in the workplace, becoming neglected by undergraduates to their own detriment, as discussed in Section 5.11.

As workloads at university level remains high, it may perhaps be prudent for UKZN to inform or teach undergraduates how to form a successful strategy to deal with their workload. Practices of consistency, time management and energy management may be discussed by lecturers. The QPA (2019) survey also revealed that 39% of graduates stated that they worked hard only around exam time. The strategy of planning and consistent work needs to be taught at university level, or graduates risk entering the workplace without the habits of consistent hard work and it may impact their success in the workplace.

5.6 An Expectation and Interest in Application

Table 4.5 indicated that 19% of respondents expect less emphasis on theory and more application. Townsend (2005) also indicated that graduates had more appreciation for application rather than theory. This is concerning as it is not the case with many companies, according to responses from R1, R2 and R3. Many companies expect their employees to tackle new and unique problems by starting from first principles and formulating a solution. Of particular concern, brought up by R2, is the over-usage of certain engineering software which exists at university but is not used by most companies, especially small companies. Engineers are thus forced to work with very basic software and develop solutions from fundamental engineering theory. The sudden lack of software available to graduates in the workplace may require significant time re-learning relevant theory associated with their duties, leading to workplace inefficiency and possibly necessitate wasteful investment in further basic training.

5.7 Expectations of Structured Guidance, Graduate and EIT Programmes

As previously mentioned, 61% of respondents expect guidance and training from their employer, towards their goal of registering as Pr.Eng. with ECSA. This guidance is expected to include a structured EIT programme for new graduates. While not necessary for initial employment, a Pr.Eng. certification is a highly coveted title and achievement among engineers, as it is often required for promotion into high-level positions and dramatically increases an engineer's employment attractiveness, thereby commanding considerably higher salaries. Howell (2016) indicated the key benefit of EIT and graduate training programmes in general is that of job rotation which grants new graduates exposure to different departments.

Unfortunately, as revealed by discussions with Academic Leaders in Section 4.6, the presence of a structured EIT programme prevails in only a handful of large industrial companies. These companies are also declining in their intake of new graduates as economic conditions worsen and it is increasingly smaller firms that many new graduates find employment in. According to R1, in Civil Engineering and allied programmes, EIT programmes are essentially non-existent even in large construction companies, but rather random mentorships prevail which differ in quality and efficiency, leaving many new engineers to their own 'wit and will' to apply and pursue Pr.Eng. registration. Even in other engineering fields, EIT programmes are present only in large companies. There is thus possibly a high mis-alignment between what new engineering graduates expect and what employers offer in this regard.

This issue seems to be compounded by ignorance over ECSA policy and guidelines. Only R2 indicated awareness of ECSA guidelines for EIT and mentorship programmes which were followed by large chemical engineering employers such as Sasol. R2 directed the study towards an ECSA document which lists the structure and broad topics to strive for in an EIT programme.

For chemical engineers, broad areas and topics are said to include:

1. Solving problems based on engineering and contextual knowledge
   1.1 Conceptualisation of complex engineering problems
   1.2 Design or development processes for complex engineering problems
2. Implementing projects or operating engineering systems or processes
   2.1 Planning processes for Implementation or Operations
   2.2 Organising processes for Implementation or Operations
   2.3 Controlling processes for Implementation or Operations
   2.4 Close out Processes for Implementation or Operations
   2.5 Maintenance and repair processes
3. Risk and Impact Mitigation
   3.1 Impact and risk assessments
   3.2 Regulatory compliance processes
4. Managing Engineering Activities
   4.1 Self-Management Processes
   4.2 Team environment
   4.3 Professional communication and relationships
   4.4 Exercising Judgement and Taking Responsibility
   4.5 Competency development

(ECSA, 2013a)

It was subsequently found that there are ECSA guidelines for mentorships and graduate training for agricultural, mechanical, civil, electrical and electronic engineers in order for the training programme to be seen as legitimate engineering work that counts as experience when applying for registration with ECSA as a Professional Engineer (ECSA, 2013b; ECSA, 2019a; ECSA, 2019b; ECSA, 2019c; ECSA, 2019d). These documents are developed in collaboration with various engineering institutes such as the South African Institute of Mechanical Engineering (SAIME), the South African Institute of Electrical Engineers (SAIEE), South African Institute of Agricultural Engineers (SAIAE) and the South African Institute of Civil Engineers (SAICE). Respondents R1, R3 and R4, however, had not mentioned these documents at all, yet R3 did express awareness that ECSA is involved in the monitoring process as well. Other academic leaders and by extension their industry partners, seemed unaware of these documents. Knowledge and awareness of these guidelines could substantially improve the quality of training programmes and even mentorships to enable new graduates to provide a quality application for Pr.Eng. registration.

5.8 Salary Expectations

Table 4.5 indicated high salary expectations of graduates for their new employment. This result is in agreement with Townsend (2005) which stated that many degrees are chosen or avoided based on the perception of the salary they command. As mentioned in Section 4.6.1 and Section 4.6.12, discussions with academic leaders revealed a general feeling that new graduate salary expectations are too high, especially considering that most new posts are offered by smaller companies rather than the larger more traditionally sought-after employers.

An overly high expectation of the very subjective topic of remuneration can negatively impact new graduates' morale as it sets them up for disappointment. Coupled with high amounts of training, intense work and high levels of responsibility, this can create workplace dissatisfaction and loss in productivity in graduates which would not necessarily exist if they had lower or more realistic expectations in the first place.

5.9 Reasons for Pursuing Engineering

Numerous reasons have been given for graduates' pursuit of an engineering degree and are outlined in 4.5. Collectively, 61% possessed a high interest in science, technology, engineering and mathematics, which is an encouraging find. There is some mis-alignment with industry expectations as R3 indicated that many companies perceived UKZN to overemphasise mathematics in the engineering programmes. However, as explained by R3 in Section 4.6.8, this overemphasis was actually beneficial as it gave graduates necessary skills to thrive in other industries such as banking and insurance.

5.10 Desire to Make an Impact

While most responses reflected inward desire for their pursuit of an engineering career, only three respondents expressed a deep desire to make a difference in society and play a role in social responsibility, particularly in the areas of sustainable development and making a positive environmental impact. This is of particular concern, especially considering that engineers play a primary role in sustainable development, pollution prevention and climate change mitigation through designing and innovating technologies for clean industrialisation that protects the environment while also propagating economic and GDP growth. R3 touched on this problem as reported by industry in Section 4.6.8. Socio economic and environmental awareness have to be instilled over time in new graduates.

While Section B of the graduate questionnaire revealed deep motives in respondents in their pursuit of their engineering degree, the written section indicates that these deep motives are still simply inward for many respondents, possibly selfish and devoid of a sense of citizenry and social responsibility. A number of previous authors have corroborated this finding (Tretko and Vashkurak, 2017; Martinez et al., 2017; Bielefeldt and Canney, 2016; Cech and Sherick, 2015; Maciejewski et al., 2017; Slaton, 2015). R3 indicated concern for where South African institutions stand in contemporary engineering education internationally and Tretko and Vashkurak (2017) found an increasing trend towards "socio-centrism" and "eco-centrism". Engineering programmes at UKZN and South African institutions in general can thus be recommended to instil greater awareness of social responsibility during their course delivery.

Such a recommendation can, however, be difficult to implement. Another important point to consider is South Africa's current economic climate. Section A of the questionnaire revealed that 14% of respondents needed to work while studying to sustain themselves and 24% had to run their own household (Table 4.2). One respondent indicated no interest in engineering but chose it because he was accepted for that choice in the application process. Even for those who have been fortunate enough to make it to the level of attending tertiary education, life is a daily struggle and the aim of overcoming one's own personal poverty and increasing one's own quality of life often takes precedence. This is apparent also when considering respondents' future goals and expected achievements. Sixteen percent of respondents (see Table 4.5) indicated their desire to have a stable income, something which R4 indicated may be more common (see Section 4.6.1.).

Knoche et al. (2013), Wolfe et al. (2016) and Itani and Srour (2016) further found that this desire to personally succeed, get out of poverty and live well also affected the amount of emphasis undergraduates placed on certain modules. Technical modules were concentrated on by undergraduates who simply had that aim of getting a good starting salary, while soft skills such as oral and written communication were under-emphasised. Attempts should thus be made to instil higher aims in all graduates; Itani and Srour (2016) also indicated that students with higher aspirations and mature plans typically left nothing underemphasised and possessed the soft skills required to excel in the workplace.

5.11 Assessment in Graduate Training Programmes

Interviewees indicated that performance in training programmes and general engineering employment depends on deliverables in the form of reports and presentations. This was corroborated by Goldsmith, Willey and Boud (2019). While not mentioned by respondents, a key mis-alignment that is systemic is that while assessment in the workplace is in the form of reports and presentations, most assessments at undergraduate level are in the form of tests and exams. While engineering programmes do introduce a significant amount of report writing and presentations in their assessments, undergraduates often try to circumvent the effort of individually writing them as mentioned by R3 in Section 4.6.8.

Although 93.4 % of graduates indicated that their degree developed their written and communication skills (QPA, 2019), high workloads and resultant surface strategies employed by a number of undergraduates contribute to many students graduating without developing good proficiency in these skills. The way work is assessed in the workplace is probably not an issue on the minds of graduates while pursuing their degree, leading to mis-alignment between graduate skill and employer expectations. R3 indicated that a key complaint from industry was related to poor technical report writing skill. Wolfe et al. (2016), Fernando et al. (2016) and Fletcher et al. (2017) reported similar complaints of low reporting and presentation skills. Fernando et al. (2016) indicated that smaller firms are much more vocal and less forgiving about this issue since they are focused on growth and efficiency.

It can be suggested that more effort be put in by programme personnel to remind undergraduates to focus specifically on becoming proficient in report writing. Timmerman et al. (2013) conducted an elaborate study of getting undergraduates to firstly write a research proposal at the beginning of their studies, followed by a proposal at the end in order to assess the differences. This strategy requires high effort on an ongoing basis. R2 indicated that often awareness can be raised while delivering the standard curriculum. Report writing also serves as evidence of built-up engineering experience over years, which may be used towards Pr.Eng. application and registration. Key implications of the failure of students and employers to invest equal value in report writing and presentation skill include employer dissatisfaction, lack of productivity and inefficiency through numerous iterations of originally substandard reports, wasteful investment in further report-writing training and delayed prospects of employee professional registration and promotion.

5.12 The Cost of Further Training

An inadequately answered question by academic leaders concerns the cost of further training incurred by companies to train new graduates. Respondents indicated short courses could cost up to R50 000 for a five-day course, which is exorbitant considering that the yearly cost of engineering undergraduate degrees is less than this. R2 indicated that in-house training incurs the indirect cost of having to take senior employees out of their productive roles in order to facilitate training of new recruits. R4 also indicated the presence of government funding for small firms to upskill new employees. Absolute costs over a two to five-year period could not be ascertained. Such information could not be found through the literature review either and the topic is highly context dependent and ever changing. This question proved to be too specific to be adequately answered by academic leaders being interviewed as proxies for employer opinion and insight. Clear answers can only be provided by companies themselves and only specific personnel in a company would know this. R3 indicated uncertainty about a company's willingness to divulge this information as it is part of their strategy.

5.13 Postgraduate Study in Engineering

Aspirations for postgraduate study in engineering fields was found to be low in Table 4.1 of the graduate survey (12%) in comparison to other fields. In the QPA (2019) survey, 92% of UKZN graduates were studying further, possibly due to various "Honours level" degrees being offered and pursued by graduates at other UKZN schools. On an encouraging note, while postgraduate enrolments in engineering are low, 27.6% of respondents of the Graduate Opinion

Survey indicated interest to study further at some point in the future, although there is no definite commitment.

Remuneration for full-time engineering postgraduate research is comparatively significantly lower than what a job in industry typically offers. Academic leader discussions have further revealed that the engineering employment market offers little to no encouragement for the pursuit of postgraduate engineering qualifications. This response was corroborated by Townsend (2005) who stated that in certain fields, especially civil engineering, occupations do not provide any reasonable monetary incentive to pursue postgraduate studies. In some cases, postgraduate level qualification may be appreciated and boost one's CV and skill set and thus employment attractiveness, but there is no definitive near-guarantee of this. Of primary recognition in industry is the possession of professional engineering registration, which is indicative of high engineering experience.

It is understandable that industry values experience. However, innovation and new technology, new systems, 'blue ocean' market creation and breakthroughs are accomplished mainly through the field of research and postgraduate studies. The absence of tangible encouragement of postgraduate research from the market ultimately reduces interest in postgraduate enrolment and incurs the risk of the market stagnating in the area of innovation (Watson, 2009). This was a clear worry of R3 who indicated the lack of exposure that engineers have in South Africa compared to the developed world, with major employers in South Africa being maintenance driven rather than innovation driven. R2 expressed that many chemical engineering graduates expect innovation, they expect to "be walking directly into some sort of design house", but that is not an expectation that would be fulfilled in most cases.

The low interest in postgraduate study is accompanied by a low interest in business creation. Only one graduate respondent expressed the immediate desire to start his/her own business. Despite possessing the scientific knowledge and notwithstanding the final-year soft-skill courses provided across all engineering disciplines, including Engineering Management and Engineering Business, new graduates still possessed the prime objective of firstly getting employed by others. However, 13% of respondents in Table 4.5 provided written responses of ambitions to start their own business in under ten years. Low interest in postgraduate studies, with low stimulation in non-innovative firms as mentioned by R3 could, if widespread, potentially paint a bleak picture for engineering innovation and engineering entrepreneurship in South Africa.

5.14 The Mismatch between Industry Needs and Undergraduate Education, an Often Natural and Positive Occurrence

Discussions with academic leaders, in particular, have revealed that a mismatch between industry needs and graduate education and skill is often natural mainly since degrees are broad based while enterprises are highly specific to certain operations. It is employers' responsibility to understand this and in many cases they have. Academic leaders have accepted that this criticism from industry will be enduring as new firms emerge and smaller companies seek to employ engineers with little idea of their capabilities. In some cases, a mismatch is most likely when employers operate and demand skill in obsolete practices while the university is responsible for giving its students contemporary and relevant skills.

5.15 Language Barriers

As mentioned in Section 4.2, 22% of respondents did not speak English as their first language and the QPA (2019) revealed that 63% of UKZN's graduates were English second-language speakers. It is possible that since engineering is a relatively difficult degree to pursue, it is still being pursued by the majority of students who speak English as their first language. As improvements in access to funding and enrolment occur, it is expected that the number of non-English-first-language speakers will increase in the future. Academic leaders attested to the effects of this at the workplace, with poor report-writing skills and communication barriers between engineers and other workmen. The study by Almeida et al. (2015) indicated that employers are generally forgiving of grammatical errors of non-English-first-language speakers and less forgiving of those whose first language is English. This is especially true of larger firms who are able to absorb these shortcomings. Nevertheless, reports must be of adequate technical quality.

R3 suggested that perhaps an English language course be incorporated into engineering curricula. However, Knoch et al. (2013) and Wolfe et al. (2016) indicated that employers of engineers were found to be most skeptical of language proficiency training courses. While such courses can improve grammar, it is the technical aspects of the report that are most important while poor grammar is often overlooked by employers.

5.16 Undergraduate Lack of Engineering Background

Respondents R2 and R4 identified systemic issues such as lack of engineering background and flair in undergraduates coming into university as problematic. Many study hopefuls are the first in their family to pursue a degree and have no social capital to ask for guidance. According to QPA (2019), 42% of graduates were the first to graduate in their family and for 65% of graduates, it is their first qualification. Many have had no background of an engineering hobby or solving practical problems and chose engineering for its gainful employment opportunities. This impacts not only graduate quality for innovation, but also basic practical engineering logic. R4 gave a case of graduates knowing complex mathematical calculations yet being unable to assess a home distributor board. This was corroborated in the works of Itani and Srour (2016), Osman et al. (2013) and Nair et al. (2009).

Interviewees indicated that most major employers have accepted that their new intakes lack experience and accept the responsibility of training them over lengthy periods of time. Fletcher et al. (2017) also indicated that the alignment between industry expectations and the reality of new graduates has greatly improved compared to 2005. There is generally no mis-alignment between employer and graduate expectations in this regard, although R2 mentioned that there are exceptions with smaller firms. This agreed with the findings of Almeida et al. (2015) who indicated that smaller firms have higher expectations, are less forgiving of shortcomings and often less accommodating of diverse language and cultural backgrounds.

5.17 Graduate Confidence Mis-alignment

Graduate confidence in tackling unfamiliar problems, planning of work and sourcing and using quality information (discussed earlier) was reportedly high, according to the majority of the graduate respondents surveyed (see Table 4.4). Table 4.5 further showed that 45% of respondents also wrote that they are generally excited and confident to join the workforce.

This confidence at graduation is not reflected by industry. Academic leaders, in particular R2 and R3, have declared that industry often reports a lack of confidence in new recruits. A previous qualitative study by Naidoo and Osman (2015), who interviewed managerial personnel from local industries, also found managers generally reported low confidence levels in new graduates concerning their ability to source quality information and report on new and unfamiliar tasks. This was further corroborated by previous works (Nair et al., 2009;

Radermacher and Walia, 2013; Osman et al., 2013). Confidence in leading projects was mentioned to be particularly lacking.

This mis-alignment and complete contrast could be symptomatic of unrealistic expectations imposed on new employees by their employers. As academic leaders have mentioned, there are a few companies who have unrealistic expectations that their graduates should be highly suited to their particular enterprise. R1 indicated numerous unreasonable demands from certain companies to teach proficiency in very specific software that they use. From the graduate side, QPA (2019) revealed that 91.5% of graduates are satisfied that their degree developed their computer skills. Given the high involvement of PC usage in engineering, it is not unexpected that all graduates have a good acquaintance with software usage and are able to pick up software skills at the workplace on their own fairly quickly.

R2 reported niche subject matter demands that certain employers want but there is no way to accommodate them in the curriculum. Smaller firms employing just a single engineer often do not know what to expect and expect too much. R3 indicated that some would suggest changes to the entire curriculum. While many of these unreasonable expectations are dismissed by academic leaders, it is possible that new graduate employees bear the brunt of these demands and find themselves lacking in certain proficiencies, thereby reducing their confidence.

5.18 ELOs and Attributes

A notable difference was evident between interviewee and industry feedback, via interviewees, on whether or not any ECSA ELOs were lacking in graduates (Questions 9 and 10 in Appendix D). Interviewees were reserved about passing on any criticism that may have emanated from industry concerning ELO’s, but less so with their own observations of ECSA attributes exhibited in graduates.

Given that it is the responsibility of the university to raise awareness and instill ECSA exit-level outcomes in undergraduates and assess whether each graduate has met those outcomes during their degree, such reserve is understandable. On one hand, any indication that graduates may be lacking in one or more ELOs can reflect poorly on that engineering discipline’s methods of instilling and assessing that ELO. There is thus some cause for respondents to be vague and possibly biased about this topic. On the other hand, graduate attributes described by ECSA are perceived to be the responsibility of the graduate her/himself and any lack of ECSA attributes in a graduate is perceived wholly as the graduate's fault. Interviewees were thus far more forthcoming and direct in listing which ECSA attributes are lacking in graduates. Respondents listed confidence, independent life-long learning and social skills as prime attributes lacking in many graduates, as presented in Section 4.6.6. This is consistent with the findings of Radermacher and Walia (2013), Khoo et al. (2016) and Osman et al. (2013).

5.19 Undergraduate Industry Participation and Vacation Work

The key theme identified by the interviewees to resolve the gap between graduate and employer expectations centred on undergraduate participation and vacation work in industry. R1 advised a more standardized approach to facilitating and monitoring IAB participation. R2, R3 and R4 recommended closer links between university staff and industry partners to achieve a high overlap and structured availability of industrial vocational training. These efforts will greatly assist in improving graduate readiness and provide graduates with a realistic view of the workplace and its expectations and also provide industry players with realistic expectations of graduate capabilities.

5.20 Responses in Light of Theoretical and Conceptual Frameworks Considered in this Study

By viewing the collective results of this study, including graduate and academic leader responses, a few key remarks can be made within the frameworks presented in Section 2.4. Academic leader interview responses indicated that at the very least, employers require new graduates to be competent or proficient in at least the first three of Bloom's categories of education, namely: knowledge/remembering; comprehension/understanding; and application. Academic leaders indicated generally that employers expect graduates to have fundamental engineering knowledge and proficiency to apply the skill of analysing often new and unique problems and to formulate solutions from first principles of engineering, no matter the field. Other categories may be developed as their career progresses and learning occurs.

The Biggs study motives and strategies framework (Biggs et al., 2001) was used abundantly in this study, particularly through the graduate questionnaire. The study found a high degree of deep thinking present in graduates. Of all respondents, 68% were found to possess a moderate to exclusively deep approach to their pursuit of an engineering degree, with 34% being exclusively deep in their approach. However, 32% were only moderately deep in their approach. Approaches in the Biggs (2001) questionnaire are a combined score assessing both study motives and learning strategies of respondents, so the challenge was to establish whether respondents were deep primarily in their motive, or in their strategy, or both. Closer examination of results in Table 4.4 revealed that for those of moderately deep approach, or tending towards a moderately mixed or surface approach, this was due most often not to possessing surface motives, but rather adopting surface strategies. Encouragingly, respondents exhibited a deep appreciation for their engineering degree and whatever they studied. They simply adopted surface strategies when trying to get through all assessments and the clue found in Table 4.5 was that this was due to the inherently high workload present in engineering curricula. In addition to high workloads, many respondents were found in Table 4.2 to work and run their own household while studying and endure many personal pressures.

Interview respondents indicated that, unfortunately for many graduates, the primary objective for pursuing engineering is to get themselves gainfully employed and get their families out of poverty. With 24% of respondents working and running their own household, this overarching reality of their lives weighs down their motives, to the point that most respondents possessed very inward, self-seeking work goals and achievements to pursue. Less objective measures of success mentioned by Arthur et al. (2005) and Hall and Chandler (2005), such as career productivity, inventiveness and innovation, were of lower priority in many new graduates' ambitions.

On the positive side, when looking at the Boundaryless career framework and the results of Table 4.2, most respondents exhibited high job mobility and high preparedness to move to wherever a job was available. Respondents exhibited high physical mobility while psychological mobility remains in question, with low confidence levels in new graduate employees likely brought about by unreasonable expectations of some employers. Graduate respondents indicated that they want growth as a high priority, but at the same time many are weighed down by personal and family responsibility. For some, psychological mobility may well be present, as they would take any employment that they get regardless of whether it is aligned to their engineering field or not. But this is ultimately a mobility driven by desperation rather than objective goal setting.

It was found that while most companies (except large companies that employ many engineers) do not have structured EIT programmes, most have some form of mentorship, whether formal or informal. In light of the Boundaryless framework, no matter what the structure is, it is perhaps important that the company be somewhat nurturing of new graduates to build their confidence, identify their strengths and give them the space to grow in the company, even beyond an engineering profession (Heslin, 2005). Should they remain in an engineering profession, employers must follow ECSA guidelines very closely to support and encourage new recruits towards achieving a Pr.Eng. registration.

Concerning the Protean Career framework, interviewees lament the lack of exposure that new engineers have access to, with most major employers being maintenance driven rather than career driven. This makes the possibility of growing graduates' motivation outside of objective measures of success very difficult and this does not bode well for value-driven, impactful innovation to occur at the workplace. Higher employer and market interest in postgraduate studies, which develop the high learning abilities of analysis, synthesis and evaluation as Bloom's taxonomy describes (Clark, 2015), can ultimately drive workplace innovation in new and growing engineers.

5.21 Conclusion

The results presented in Chapter 4 have been thoroughly assessed and numerous expectations and mis-alignments have been presented and discussed in light of previous findings in literature and in light of the frameworks used in this research. The effects of mis-alignment on innovation have been discussed and, where possible, reasons for mis-alignment have also been identified and explored. The next chapter summarizes findings in light of the objectives of this study, in order to provide recommendations particularly to UKZN, for the role it can play in improving upon issues of mis-alignment and its effects.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

Numerous sources in literature were found to indicate mis-alignments between engineering graduate expectations, employer expectations and reality. The potential implications of this mis-alignment, if sustained and unabated for a long period of time in the context of private and public sector corporations, were identified to include workplace dissatisfaction, lack of productivity, inefficiencies, high investments in unproductive operations such as employee training, often with low return on investment and potential lack of innovation and competitiveness of organisations. It was thus found to be highly relevant and necessary to assess the extent and nature of such mis-alignments in order to develop mitigating solutions.

The aim of this research, as stated in Chapter 1, was initially to assess the alignment (or mis-alignment) between UKZN's new engineering graduates' expectations and attitudes towards the workplace, with that of expectations and deeply sought-after values of engineering employers. The final objective was to identify areas where UKZN, in particular the School of Engineering, can play a role in mitigating or improving this alignment. To accomplish this assessment, credible data had to be collected. Two populations were surveyed, namely the engineering graduates who attended the April 2019 Graduation ceremony and the academic leaders of each discipline in the School of Engineering at UKZN.

Engineering graduates were surveyed quantitatively through the issuing of a questionnaire. Fifty responses were received out of a total sample size of 120 graduates and a population size of 393 engineering graduates. The questionnaire consisted of three sections: assessing biographical information, the motives and learning strategies of graduates as they pursued their degree and their expectations and goals for the future.

Engineering academic leaders were surveyed qualitatively through their participation in semi-structured interviews. Academic leaders were seen as valid proxies for the opinions of engineering employers in industry, due to their rigorous and experienced liaison and interaction with industry over the years.

A third source of information that was considered was the results of the UKZN QPA Department's Graduate Opinion Survey (QPA, 2019), which gave further insights and general university-wide data. This survey provided a secondary source of information to add more credibility, validity and reliability of findings in this work.

All details of the survey methods have been presented in Chapter 3, while results were presented in Chapter 4. The results were assessed in Chapter 5, where graduate responses were compared with the insights of academic leaders to identify any mis-alignments between graduate expectations, employer expectations and reality.

This chapter presents key findings in reference to the objectives of this research.

6.2 Conclusions Concerning the Research Methodology Used in this Study

The convenience sampling strategy of surveying graduates during the graduation ceremony was beneficial in terms of the unparalleled access granted to a large and diverse population of engineering graduates in a single sitting. No reasonable difference can be discerned between a graduate who attended the ceremony and one who did not. However, the strategy possessed a drawback as achieving a high response rate was not possible as graduate enthusiasm to answer a questionnaire was understandably low due to the event's competition for graduate interest. Graduate willingness to provide written answers during the event was even lower. The strategy nevertheless secured 50 respondents with adequate diversification from which to derive credible findings. The low response rate can be overcome by increasing the sample size to include the entire population, as is attempted by UKZN QPA (2019).

The use of secondary information from UKZN's QPA (2019) Graduate Opinion Survey provided extremely helpful insight which not only added credibility to this study's survey responses but also provided additional angles to relevant discussions.

The incorporation of the condensed version of the Biggs SPQ (Biggs, 2001) in the graduate questionnaire provided, through cross-examination, assistance with identifying and separating graduates' motives from their strategies and behaviours. This gave insight into factors that drive their motives, strategies and goals for the future. Other frameworks, including Bloom's taxonomy, Boundaryless and Protean careers were also found to be highly relevant in the analysis and discussion of graduate expectations and where they emanate from.

The surveying of academic leaders as proxies for industry opinion possessed many benefits and a few drawbacks. Eleven themes were successfully investigated, with further themes inductively established and discussed. The survey was beneficial as the interviewing of four academic leaders granted access to the opinions of over 14 companies. Responses relevant to the objectives of this research were useful and adequate. An important benefit was that the opinions of industry partners were placed in good context to also establish the validity of their opinions in light of the realities of engineering education. The interviewing of actual industry partners would have resulted in very specific responses that would be difficult to contextualise and difficult to ascertain their validity. Many more interviews would have needed to be conducted and securing the appropriate interviewees would have been logistically challenging.

One drawback of interviewing academic leaders was that such respondents did not possess specific information as to absolute costs incurred by companies for training and upskilling new employees. Another minor drawback was the possibility of inherent bias concerning whether any ELOs in graduates were found lacking by industry, because this may have been viewed as a poor reflection on the UKZN Engineering Programme. Such bias, however, is redundant as the interviewing of employers directly would have also incurred bias in other areas such as graduate training and postgraduate qualification.

6.3 Key Findings Concerning the Objectives of this Study

The study pursued four objectives. Findings related to each objective are provided below.

6.3.1 Objective 1

- To determine the employment and daily work expectations of newly graduated UKZN engineering students.

Graduates were identified to have a number of varying expectations. However, the biggest general expectations reported were growth opportunities, followed by an alignment to their field of study and high remuneration. Most graduates indicated that they expect to be placed in a graduate training programme, with a formal EIT programme being the most common expectation.

These expectations were driven largely by deep motives exhibited by graduates. In Section B of the graduate questionnaire, graduates generally exhibited high interest in their degree and wanted to learn more. Many expect guidance towards growth and eventual professional registration with ECSA. However, the majority of motivations were found to be driven by personal interests and personal goals, with little outward drive to make an impact in society. Many are prepared to accept a job that forgoes alignment to their engineering field of study and are highly job mobile. This too was driven by personal motivations of gainful employment to meet family responsibilities.

Graduates had very mixed perceptions of how they would experience daily work. While not specifically asked, responses focused primarily on workload, with an equal number expecting a higher and a lower workload. The workload encountered in engineering degrees emerges as a dominant theme in this study, resulting in many graduates adopting surface strategies just to get through their degree despite having deep motives. Another popular workplace expectation was more application of knowledge and less focus on theory and conceptualisation.

6.3.2 Objective 2

- To ascertain the expectations of engineering employers in KwaZulu-Natal concerning newly-employed graduates.

All employer expectations were ascertained indirectly by interviewing academic leaders of each engineering discipline at UKZN. The validity and trustworthiness of using academic leaders as proxies for determining employers' views and expectations have been discussed in Section 3.8.

Employers were reported by academic leaders as generally expecting new graduate engineers to have a good foundation of basic engineering skills, problem solving and analytical skills and to be able to be given new problems and derive solutions from fundamental theory. Most employers were said to accept as reality that they will have to provide further training to new graduates. However, only a few large companies put their new graduates through a structured EIT programme, with most small companies merely possessing mentorship programmes of varying quality and differing degrees of alignment to ECSA guidelines.

Numerous companies were stated to have unrealistic expectations of new graduates. These expectations pertain mostly to proficiency with highly specific software and knowledge of specific engineering processes in that industry; this has reportedly been an ongoing issue that in the opinion of academic leaders will never end. Smaller firms with low experience in employing engineers and at the same time who are increasingly employing higher numbers of engineering graduates, were often stated to not know what to expect and thus have unrealistic expectations.

6.3.3 Objective 3

- To identify any positive and negative trends that employers have observed over time with new graduate intakes.

A key negative trend identified by academic leaders was inadequate communication and report writing skills. As non-English-first-language speaker enrolment has increased over the years, employers have reportedly experienced reduced quality in technical-report-writing skills in English. Language barriers and 'silo' thinking also persists between engineers and foremen in the workplace. The number of high-performing engineers was also perceived by academic leaders to be decreasing and the reasons were thought to be systemic, emanating from poor quality of high school education. Another systemic negative trend is the decline of engineering enthusiasts who dabble in gadgetry from a young age and develop a very practical understanding of how things work. Many graduates were reported to be proficient in complex tasks but were ignorant of very simply controls and processes. This trend was perceived by academic leaders to be due to a lack of engineering social capital, with many engineering graduates being the first in their family to obtain a degree. This also contributed significantly to a lack of confidence exhibited by new recruits.

A positive trend apparently reported by employers has been increased teamwork ability due to undergraduate projects increasingly being conducted as group projects rather than individual projects. Another trend reported by academic leaders was the increased expectation of employers for graduates to be proficient in software and electronic control aspects of engineering. In this regard engineering disciplines are perceived to be converging and a big concern for academic leaders is the available exposure that a country like South Africa can provide to new engineers compared to the developed world.

6.3.4 Objective 4

- To establish ways in which UKZN could assist in bridging the gap between graduate and employer expectations to ensure successful productivity.

A number of suggestions have been made by academic leaders, according to which UKZN can act to mitigate gaps between graduate and employer expectations. The first suggestion made was increased standardising of the discipline's approach to IABs. Currently, this is highly informal, disjointed and dependent on the self-motivation of academics and academic leaders of various disciplines, with no input, guidance, monitoring or support from School or College level. A more standardised approach was advised.

Another prominent suggestion by academic leaders concerned the issue of vacation work for students. Closer ties and relationships with industry must be formed by academics to facilitate vacation work for undergraduates. The approach to vacation work must be standardised and a single platform should be created for industry to advertise vacation work and liaise with engineering undergraduates. Graduates require a compulsory 12 weeks of vacation work as part of their degree completion. If planned together and correctly, the undergraduates would benefit by getting key industry exposure and industry would benefit in the short term by getting cheap/free labour to work on minor projects that are otherwise too expensive or time consuming to pursue. The long-term benefits will be graduates who are better acquainted and prepared for productive work in an organisation.

Through the combined analysis of graduate and academic leader responses, there are many other strategies and recommendations uncovered throughout the study. As workloads remain high and many undergraduates’ readiness for tertiary education is questionable, it is advisable that UKZN Engineering endeavours to provide supplementary courses on consistency and time management to make undergraduates successful in getting the most out of their studies, despite the fact that many need to work and run their own household while studying.

While graduate confidence was generally found to be high, confidence of new employees at the workplace was reportedly low, likely brought on by unreasonable expectations thrust upon new employees (as stated by academic leaders). UKZN may be advised to improve its industry liaison efforts to provide industry with an accurate expectation of graduate capabilities and to encourage a nurturing workplace environment even in small upcoming businesses that envisage growth.

The graduate expectation of a structured EIT programme was, according to academic leaders, found to be misaligned with reality in all but a few major employers. Nevertheless, the expectation of at least some quality mentorship or guidance towards Pr.Eng. registration is a justified expectation, since ECSA provides guidelines for quality mentorships and structured programmes. Knowledge of these guidelines was not well exhibited by some academic leaders and not by many industry employers either. UKZN Engineering can thus be advised to raise awareness of these guidelines among academic staff, undergraduates and industry partners to increase the number of professional engineers in the industry. The presence of registered professional engineers in an organisation greatly uplifts the credibility and reputation of that organisation to be one that commands engineering authority and reliability in pursuing engineering projects and thus a key competitive advantage in the engineering world.

Tangible interest in postgraduate study was indicated by academic leaders to be low and not encouraged by the market. This is linked to declining innovation in South African engineering firms as new engineers are not equipped with the learning abilities or resources to pursue new ideas and innovate new solutions to remain competitive. Interest in postgraduate study must be spurred on by UKZN industry partners to convince them to encourage and incentivise their engineers to pursue postgraduate study and gain the skills required to research and innovate new ideas efficiently and effectively. There are also various government and tax incentives which UKZN may investigate to encourage employers to upskill their employees.

Greater effort must be pursued by UKZN Engineering to instil a sense of importance in students for perfecting their presentation and report-writing skills, stated by academic leaders and literature sources to be the typical format in which performance is assessed in industry. Emphasis on perfecting knowledge in fundamental engineering modules must also be made as graduates are often given little software resources in industry and are expected to find solutions to novel problems from first principles.

6.4 Recommendations Derived from the Study

Recommendations on future action as a result of the findings obtained in this research are covered in Section 6.2.4 when addressing Objective 4. These are briefly listed below, together with other recommendations.

- There should be a more formal and standardised approach to maintaining IABs at the school, college, or university level rather than just the discipline level.
- A standardised approach towards vocational training is advised, including a single platform where employers and academics can post vocational training advertisements and students may apply. Funding opportunities for these posts may also be listed.
- Supplementary courses on study and planning strategies should be introduced to inform undergraduates on how to succeed and get the most out of their studies despite high workloads and responsibilities. Deep motives and strategies must be encouraged.

- Closer ties between UKZN and industry partners must endeavour to better align employer expectations with the reality of graduate capabilities and graduate expectations of the workplace. This includes greater involvement of industry in assessments.
- Greater awareness must be raised within UKZN and industry employers to develop mentorship, graduate and EIT programmes that are in line with ECSA guidelines and stipulations, in order to better prepare and develop new graduates towards registering as professional engineers.
- More emphasis must be given by UKZN and within industry to encourage postgraduate study, to develop higher learning and investigative skills and ultimately encourage innovation. UKZN may assist with guidance in all processes of postgraduate study, while industry may incentivise employees to pursue postgraduate study.
- Increased emphasis must be placed on report writing and presentation skills at the undergraduate level, to better prepare graduates for assessments in the workplace.
- The importance of undergraduates developing and perfecting, rather than neglecting general, transferable soft skills must be better emphasised.
- Elevated interest must be encouraged among students concerning fundamental courses and first principles in engineering to enable graduates to confidently solve problems using strong fundamental knowledge even without the need of often unavailable software.
- Engineering modules must be developed to include greater environmental and social awareness and inspire graduates towards outward-focused motives in addition to their individual goals.
- Greater social outreach by UKZN is recommended to inspire engineering enthusiasm in children and young adults in order to pursue engineering with a passion rather than simply the motive of being gainfully employed.

6.5 Recommendations for Future Research

This study focussed on engineering graduates and graduates were surveyed during their graduation ceremony. This strategy was found to incur low response rates. A higher response rate to the graduate survey can be obtained if the survey was changed to include the surveying of final year undergraduate students in class as well. More time and planning would, however, be required to survey a class in each engineering discipline.

Graduate response rates to questions that required written responses were lower than other sections of the questionnaire. A higher response rate to written responses can be obtained by shortening the biographical section and possibly eliminating the SPQ section. Shorter questionnaires are more likely to be responded to in full, although information on study motives and strategies would not be well assessed.

This study focused on UKZN engineering graduates and UKZN academic leaders, thus deriving opinions of employers that liaised with UKZN staff. The study can be extended to survey graduates and academic leaders of other accredited engineering schools in South Africa and be further extended to include direct surveying of key industry personnel in ECSA. Academic leaders will not necessarily hold Pr.Eng. registration. Interviews with active ECSA personnel who possess Pr.Eng. registration and who are involved in accreditation reviews for South African universities can not only provide insight into the process and the rigours of obtaining Pr.Eng., but also extend the study to a context of all South African institutions.

Issues pertaining to new recruits' actual experiences of the workplace can also be investigated through interviewing newly-employed engineers currently in EIT programmes, as well as any unions or bargaining council members who represent their interests.

6.6 Conclusion

This study was inspired and first initiated through informal discussions involving academics and industry partners at the workplace, which made clear the necessity of performing a thorough assessment of the alignment between graduate expectations, employer expectations and reality. This formed the main aim of the study as it would identify areas where UKZN, in particular, can play a role in mitigating or improving this alignment and serve as a strong foundation for future changes in curricula, teaching and learning; the way relationships between UKZN and industry are managed and strengthened benefit all participants in the field, especially students and new graduates.

Four objectives were successfully pursued and explained above. A literature review of engineering employment, graduate throughput, the UKZN School of Engineerin, and the engineering accreditation body known as ECSA was conducted. This was followed by a literature review of frameworks relevant to teaching and learning, graduate motivation and strategies and new graduate careers. A general review of contemporary issues in engineering education was conducted, followed by a specific review of graduate and employer expectations, which ultimately consolidated the relevance of this study as not only applicable to UKZN engineering, but valuable to other tertiary institutions and engineering education research in general.

A research methodology was set up consisting of quantitative and qualitative elements, surveying graduates through questionnaires and academic leaders via interviews. Convenience sampling and thereafter stratified probability sampling was used for graduates, while academic leaders were specifically sought based on their position and industry liaison efforts with industry. Graduate demographics, study motives and strategies and career aspirations were sought and analysed as descriptive statistics, while academic leader responses were transcribed and analysed qualitatively, primarily using deductive semantic thematic analysis.

In summary, the research methodology presented in Chapter 3 was largely successful in establishing tangible findings relating to graduate and employers' expectations. Results were collated and compared between graduate and academic leader responses and to that of previous works in literature and within the frameworks presented herein. The frameworks in Chapter 2 were found to be suitable for use in analysing results and assessing the alignment between graduate and employer expectations. Numerous key findings and tangible recommendations were derived.

This chapter concludes the report and this study by evaluating the research methodology and findings in relation to the objectives set out in this research. Recommendations derived from the study have also been listed, together with recommendations for future research.

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APPENDIX A: Informed Consent Letter for Graduates

Informed Consent Letter 3C – To be retained by participant

UNIVERSITY OF KWAZULU-NATAL

GRADUATE SCHOOL OF BUSINESS AND LEADERSHIP
MBA Research Project - Protocol Reference: HSS/0188/019M
Researcher: Dr Khalid Osman (Tel no. 0312601674)
Supervisor: Prof. Cecile Gerwel Proches (0312608318)
Research Office: Ms P Ximba (0312603587)

Engineering Students and Their Prospective Employers – Expectations and Reality

Dear Respondent,

I, Khalid Osman am a Master in Business Administration student, at the Graduate School of Business and Leadership, of the University of KwaZulu-Natal. You are invited to participate in a research project entitled: "Engineering Students and Their Prospective Employers – Expectations and Reality"

The aim of the study is to grant the Engineering School at UKZN, and wider engineering educators in general, definitive insight into the perceptions and expectations of engineering graduates as they enter into the working world. Together with employer questionnaires, we hope to attain insight on the working relationship between employers and their graduate employees in order to better deliver our degree offering, and minimize the burdensome cost of further graduate training and development often incurred by industrial firms to meet desired competence.

Through your participation I hope to understand the perceptions and attitudes inculcated in you as a result of your tertiary education at UKZN, and your expectations of employment and daily work duties as an engineering graduate entering the labour market. The results of this questionnaire are intended to contribute towards better alignment of subject matter and course delivery with what is truly valued and desired in contemporary industry.

Your participation in this project is voluntary. You may refuse to participate or withdraw from the project at any time with no negative consequence. There will be no monetary gain from participating in this study. You are encouraged to answer frankly and honestly, with assurance of no negative consequences arising from your responses. Confidentiality and anonymity of records identifying you as a participant will be maintained by the Graduate School of Business and Leadership, UKZN. If you have any questions or concerns about participating in this study, you may contact me or my supervisor at the numbers listed above. The questionnaire should take about 10-15 minutes to complete. I hope you will take the time to participate.

Sincerely

Investigator's signature________________________ Date_________________

UNIVERSITY OF KWAZULU-NATAL
GRADUATE SCHOOL OF BUSINESS AND LEADERSHIP

MBA Research Project - Protocol Reference: HSS/0188/019M
Researcher: Dr Khalid Osman (0312601674)
Supervisor: Dr Cecile Gerwel Proches (0312608318)
Research Office: Ms P Ximba (0312603587)

CONSENT

I……………………………………………………………………………(full names of participant) hereby confirm that I understand the contents of this document and the nature of the research project, and I consent to participating in the research project.

I understand that I am at liberty to withdraw from the project at any time, should I so desire.

I hereby consent/do not consent to completing the Questionnaire.

SIGNATURE OF PARTICIPANT DATE

…………………………………………………………………………………………………

This page is to be retained by the researcher

APPENDIX B: Informed Consent Letter for Academic Leaders

UNIVERSITY OF KWAZULU-NATAL

GRADUATE SCHOOL OF BUSINESS AND LEADERSHIP
MBA Research Project - Protocol Reference: HSS/0188/019M
Researcher: Dr Khalid Osman (0312601674)
Supervisor: Prof. Cecile Gerwel Proches (0312608318)
Research Office: Ms P Ximba (0312603587)

Engineering Students and Their Prospective Employers – Expectations and Reality

Dear Respondent,

I, Khalid Osman am a Master in Business Administration student, at the Graduate School of Business and Leadership, of the University of KwaZulu-Natal. You are invited to participate in a research project entitled: “Engineering Students and Their Prospective Employers – Expectations and Reality”

The aim of the study is to gain insight into the experiences and expectations of engineering employers regarding the quality of new graduates under their employ. The study aims to gain insight into graduate expectations and performance in engineer-in-training (EIT) programmes and other equivalent training that employers of engineering graduates conduct and make their graduates undergo.

There are a myriad of further education and training courses by various institutions, offered typically as costly short courses for employees to further their education. Higher quality education at undergraduate level, that produces higher quality graduates requiring less further education and training, thus makes better business sense. Together with graduate questionnaires, I hope to attain insight into the working relationship between employers and their graduate employees in order to better deliver our degree offering, and minimize the burdensome cost of further graduate training and development often incurred by industrial firms to meet desired competence. Through your participation in this interview and experience with industrial advisory boards and other accreditation institutions, I hope to understand and quantify the cost to industry incurred through further training of new graduates to reach desired levels of competency required for successful and productive work. Your responses in this interview are intended to contribute towards better alignment of subject matter and course delivery with what is truly valued and desired in contemporary industry.

Your participation in this project is voluntary. You may refuse to participate or withdraw from the project at any time with no negative consequence. There will be no monetary gain from participating in this study. You are encouraged to answer frankly and honestly, with assurance of no negative consequences arising from your responses. Confidentiality and anonymity of records identifying you as a participant will be maintained by the Graduate School of Business and Leadership, UKZN. If you have any questions or concerns about participating in this study, you may contact me or my supervisor at the numbers listed above. The interview should take up to an hour to complete.

Sincerely
Investigator’s signature________________________ Date_________________

Informed Consent Letter 3C

UNIVERSITY OF KWAZULU-NATAL
GRADUATE SCHOOL OF BUSINESS AND LEADERSHIP

MBA Research Project
Researcher: Dr Khalid Osman (0312601674)
Supervisor: Prof Cecile Gerwel Proches (0312608318)
Research Office: Ms P Ximba (0312603587)

CONSENT

I…………………………………………………………………………(full names of participant) hereby confirm that I understand the contents of this document and the nature of the research project, and I consent to participating in the research project.

I understand that I am at liberty to withdraw from the project at any time, should I so desire.

I hereby consent/do not consent to completing the interview.

SIGNATURE OF PARTICIPANT DATE

…………………………………………………………………………………………………

This page is to be retained by the researcher

APPENDIX C: Graduate Questionnaire

A) Biographical Section (Please answer by filling the appropriate number in the box provided)

No.	Question	Answer
1	Please Select your age group 1. 18 to 21 2. 22 to 25 3. 26 to 35 4. 36 to 45 5. Above 45	
2	Please select your race 1. Black 2. White 3. Coloured 4. Indian 5.Other	
3	Please select your gender 1. Male 2. Female	
4	Home Language (state the language in which you converse with your parents/family) 1. English 2. Zulu 3. Afrikaans 4. Other South African language (eg. Xhosa, Suthu etc.) 5. Other international language (eg. French, Swahili, Hindi, Mandarin etc.)	
5	Second Language (state the next language in which you are most comfortable and good at conversing) 1. English 2. Zulu 3. Afrikaans 4. Other South African Language (eg. Xhosa, Suthu, etc.) 5. Other international language (eg. French, Swahili, Hindi, Mandarin etc.)	
6	Did you work (ie. Have a job) while studying? 1. Yes 2. No	
7	Was work (ie. Having a job) absolutely necessary to sustain your life as a student (ie. during the semester)? 1. Yes 2. No	
8	Did you have to run your own household (ie. Cook/obtain your own food, do your own laundry etc.) while studying? 1. Yes 2. No	
9	Please select your field of Engineering 1. Agricultural/Bioresources Engineering 2. Chemical Engineering 3. Civil Engineering 4. Electrical, Electronic and Computer Engineering 5. Mechanical Engineering 6. Construction Studies 7. Land Surveying	
10	Please select your employment status 1. Have already been offered a job and accepted it 2. Have received job offers but have yet to accept it 3. Unemployed and applying for jobs	

	4. Pursuing full-time postgraduate study 5. No job applications, trying to start a business instead	
11	What is the **most important** factor for you accepting a job offer? 1. High remuneration offer 2. Proximity to current city/region of residence 3. Further training and growth opportunities within the company 4. Alignment to the engineering field for which you studied 5. Long term employment contract certainty (eg. Permanent or fixed term etc.)	
12	What is the **second most important** factor for you accepting a job offer? 1. High remuneration offer 2. Proximity to current city/region of residence 3. Further training and growth opportunities within the company 4. Alignment to the engineering field for which you studied 5. Long term employment contract certainty (eg. Permanent or fixed term etc.)	
13	What is the **least important** factor for you accepting a job offer? 1. High remuneration offer 2. Proximity to current city/region of residence 3. Further training and growth opportunities within the company 4. Alignment to the engineering field for which you studied 5. Long term employment contract certainty (eg. Permanent or fixed term etc.)	

B) Study Process Section (Please answer by filling the appropriate number in the box provided)

Please take note of the key below when answering the following questions:

5 - Always or almost always true of me
4 - Frequently true of me
3 - True of me about half the time
2 - Sometimes true of me
1 - Never or only rarely true of me

Question	**Answer**
1. I found that at times studying gave me a feeling of deep personal satisfaction.	
2. I found that I had to do enough work on a topic so that I can form my own conclusions before being satisfied.	
3. My aim was to pass the course while doing as little work as possible.	
4. I only studied seriously on what was given out in class or in the course outlines.	
5. I now feel that virtually any topic can be highly interesting once I get into it.	
6. I found most topics interesting and often spent extra time trying to obtain more information about them	

7. I did not find my course very interesting so I kept my work to the minimum.	
8. I learned some things by rote, going over and over them until I knew them by heart even if I didn't understand them	
9. I found that studying academic topics could at times be as exciting as a good novel or movie	
10. I tested myself on important topics until I understood them completely.	
11. I found that I could get by in most assessments by memorising key sections rather than trying understand them	
12. I generally restricted my study to what was specifically set as I thought it unnecessary to do anything extra	
13. I worked hard at my studies because I found the material interesting.	
14. I spent a lot of my free time finding out more about interesting topics which were discussed in different classes.	
15. I found it generally not helpful to study topics in depth. It confused and wasted time, when all one needed is a passing acquaintance with topics.	
16. I believe that lecturers shouldn't have expected students to spend significant amounts of time studying material everyone knows won't be examined.	
17. I came to most classes with questions in mind that I wanted answers for.	
18. I made it a point of looking at most of the suggested readings that went with the lectures.	
19. I saw no point in learning material which was not likely to be in the examination.	
20. I found that the best way to pass examinations was to try to remember answers to likely questions	
21. I now feel confident about tackling unfamiliar problems	
22. I am now confident in my ability to plan my own work	
23. I am now confident in my ability to source and use quality information	

C) Written component:

1. In your opinion, what were the best aspects of your degree?

____

____

____

2. In your opinion, what aspects of your degree were most in need of improvement?

3. How do you think daily work life and expectations would be different from that of university life?

4. How and why did you decide to pursue a degree in Engineering?

5. What do you hope to become/achieve with an Engineering degree and what guidance do you expect from your employer? (State if any, 5 year goals, 10 year goals, life goals)

6. Are you currently employed? If so, please state the name of the company that you are employed at, and describe your duties. Alternatively provide the industry in which you are employed.

7. As an estimate, what do you hope your monthly earnings (before tax) would be in the first two years of employment as an engineer?

8. Are you excited about going to work? Are there any aspects of employment and daily work as a newly graduated engineer that you find daunting, stressful, perhaps scary or causing unease for the future?

APPENDIX D: Academic Leader Interview Schedule

1. In your opinion, what are the employment and daily work expectations of newly graduated UKZN engineering students?
2. In your opinion, what are the expectations of engineering employers in KwaZulu-Natal concerning newly employed graduates?
3. Are there any positive and negative trends that employers have observed over time with new graduate intakes?
4. What are your thoughts about global and local surveys indicating that there is a mismatch between what is being taught at undergraduate schools and the needs of industry? Please discuss your observations from your work experience and interaction with various partners in industry.
5. Have postgraduate qualifications increased employment attractiveness in your industry, and in your observation is there a difference in employer satisfaction when hiring new graduates to hiring those coming out with a higher qualification? Please elaborate.
6. In your industry, is there a structured EIT programme provided by the major industry employers, and what do EIT programmes typically entail? Please elaborate.
7. How is the performance of the individual in the graduate training programme being assessed? Furthermore, what interventions have companies implemented to support the new employees?
8. On average, how much of funds are invested on newly employed engineering graduates in way of further training and development/short courses over a 5 year period?
9. In your experience, what are the most crucial exit level outcomes of current graduates that industry partners and employers find most lacking? (Follow up with topics of: Problem solving; Application of Scientific and engineering knowledge; Design; Investigations, experiments and data analysis; Engineering methods, skills and tools, including Information Technology; Professional and technical communication; Impact of Engineering activity; Individual, team and multidisciplinary working; Independent learning ability; Engineering Professionalism; Engineering Management).
10. In your experience, what are the most crucial attributes of current graduates that industry partners and employers find most lacking? (Follow up with topics of: confidence, motivation, independent life-long learning skill and attitude, delivery of results, social skills, time management, team skills).
11. What are typical courses/workshops/presentations that graduates in your field attend for further development of their abilities (engineering or otherwise) while in their current employment? If possible, please state the names of popular courses/workshops of programmes.
12. In your knowledge and discussions with various industry players over the years, what skills and/or knowledge has industry required of these graduates that you feel were not adequately instilled/covered/emphasized in the undergraduate Engineering programme? Please elaborate.
13. In your knowledge and discussions with various industry players over the years, what skills and/or knowledge provided in the undergraduate Engineering programme do you

feel are over-emphasized (at least in graduates perceptions) and will have little or no use to the current or future duties of graduates? Please elaborate.

14. Which companies have over the past 10 years been involved in the curriculum development, feedback or reviews of any undergraduate teaching programmes at UKZN, for example, Industrial Advisory Boards, industry or design projects?
15. What have been the typical recommendations of companies in industry regarding changes and improvements in teaching and learning policies, curriculum design at UKZN and other HEI's?
16. What suggestions do you have for UKZN to assist in bridging the gap between student and employer expectations to ensure successful productivity?
17. Is there anything else that you would like to add?

APPENDIX E: Certificate of Language Editing

G and S Robinson
10 Westcliffe Avenue
Westville
3629

27 November 2019

Khalid Osman (PhD.Eng. Chemical)
University of KwaZulu Natal
Discipline of Chemical Engineering
Tel: 031 260 1674
Email: osman@ukzn.ac.za

Dear Dr Osman,

Editing Services

Thank you for the opportunity to edit your Master's dissertation:

Engineering students and their prospective employers – expectations and reality

We are pleased to advise you that we have completed the necessary editing work on your dissertation in preparation for submission. We confirm that the English language usage is of an acceptable academic standard.

Should you have any queries, or require us to do any further work, please do not hesitate to contact us.

Yours sincerely,

Gail and Shaun Robinson

G. S. Robinson MA PopStudies (cum laude) (UKZN)
071 352 8912/ gailsusanrobinson@gmail.com

S. P. Robinson MA SA Lit (University of Natal)
083 389 1822/ srobinson@wbhs.co.za

APPENDIX F: Turnitin Report

Engineering Students and their Prospective Employers – Expectations and Reality

ORIGINALITY REPORT

7%	5%	2%	6%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to University of KwaZulu-Natal	Student Paper	1%
2	ir.uiowa.edu	Internet Source	1%
3	researchspace.ukzn.ac.za	Internet Source	<1%
4	www.ecsa.co.za	Internet Source	<1%
5	uir.unisa.ac.za	Internet Source	<1%
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7	repository.up.ac.za	Internet Source	<1%
8	Submitted to Regenesys Business School	Student Paper	<1%
9	N. Rooplall, A. Marnewick, J. H. C. Pretorius.		

APPENDIX G: Ethical Clearance and Gatekeeper's Letters

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

5 March 2019

Dr Khalid Osman (SN 205500731)
Graduate School of Business and Leadership
College of Law and Management Studies
Westville Campus
UKZN
Email: osman@ukzn.ac.za

Dear Dr Osman

RE: PERMISSION TO CONDUCT RESEARCH

Gatekeeper's permission is hereby granted for you to conduct research at the University of KwaZulu-Natal (UKZN) towards your postgraduate studies, provided Ethical clearance has been obtained. We note the title of your research project is:

"Engineering Students and their Prospective Employers – Expectations and Reality."

It is noted that you will be constituting your sample by handing out questionnaires and or conducting interviews with final year and newly graduated students in the Discipline of Engineering on the Westville Campus.

Please ensure that the following appears on your notice/questionnaire:

- Ethical clearance number;
- Research title and details of the research, the researcher and the supervisor;
- Consent form is attached to the notice/questionnaire and to be signed by user before he/she fills in questionnaire;
- gatekeepers approval by the Registrar.

You are not authorized to contact staff and students using 'Microsoft Outlook' address book. Identity numbers and email addresses of individuals are not a matter of public record and are protected according to Section 14 of the South African Constitution, as well as the Protection of Public Information Act. For the release of such information over to yourself for research purposes, the University of KwaZulu-Natal will need express consent from the relevant data subjects. Data collected must be treated with due confidentiality and anonymity.

Yours sincerely

[redacted]

REGISTRAR

Office of the Registrar
Postal Address: Private Bag X54001, Durban, South Africa
Telephone: +27 (0) 31 260 8005/2206 **Facsimile:** +27 (0) 31 260 7824/2204 **Email:** registrar@ukzn.ac.za
Website: www.ukzn.ac.za

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YAKWAZULU-NATALI

03 April 2019

Dr Khalid Osman (205500731)
Graduate School of Business & Leadership
Westville Campus

Dear Dr Osman,

Protocol reference number: HSS/0188/019M
Project title: Engineering students and their prospective employers – Expectations and reality

Approval Notification – Expedited Application

In response to your application received on 05 March 2019, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol has been granted **FULL APPROVAL.**

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number. PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for a period of 3 years from the date of issue. Thereafter Recertification must be applied for on an annual basis.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfu[redacted]

....................[redacted]....................
Dr Rosemary Sibanda (Chair)

/ms

Cc Supervisor: Professor Cecile Gerwel Proches
cc Academic Leader Research: Professor Muhammad Hoque
cc School Administrator: Ms Zarina Bullyraj

Humanities & Social Sciences Research Ethics Committee
Dr Rosemary Sibanda (Chair)
Westville Campus, Govan Mbeki Building
Postal Address: Private Bag X54001, Durban 4000
Telephone: +27 (0) 31 260 3587/8350/4557 **Facsimile:** +27 (0) 31 260 4609 **Email:** ximbap@ukzn.ac.za / snymanm@ukzn.ac.za / mohunp@ukzn.ac.za
Website: www.ukzn.ac.za

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

13 September 2019

Dr Khalid Osman (205500731)
Graduate School of Business & Leadership
Westville Campus

Dear Dr Osman,

Protocol reference number: HSS/0586/019M (Linked to HSS/0188/019M)
Project title: Engineering students and their prospective employers – Expectations and reality

Approval Notification – Expedited Application (PHASE 2)

In response to your application received on 12 June 2019, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol has been granted **FULL APPROVAL**.

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number. PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only <u>valid for a period of 1 year</u> from the date of issue. Thereafter Recertification must be applied for on an annual basis.

I take this opportunity of wishing you everything of the best with your study.

Yours faith[redacted]

..................[redacted]....................
Dr Rosemary Sibanda (Chair)

/ms

Cc Supervisor: Professor Cecile Gerwel Proches
cc Acting Academic Leader Research: Dr Emmanuel Mutambara
cc School Administrator: Ms Zarina Bullyraj

Humanities & Social Sciences Research Ethics Committee
Dr Rosemary Sibanda (Chair)
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