**An investigation of industry expectations on Industrial Engineering graduates: A case study of graduate development programmes in South African universities**

A Research Dissertation by

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**Supervisor: Prof. Mellet Moll**

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## DECLARATION

I declare that this research project is my own. The purpose hereof is in fulfilment for the degree of Masters in Quality, Department of Industrial and Systems Engineering (DISE), Cape Peninsula University of Technology (CPUT). This report has not been submitted for any degree and/or examination at any other tertiary institution before. I further declare that the CPUT ethical research committee awarded me the consent to carry out this research.

Signature: ____________________

W.K. Ng’etich

Date: Wednesday, 14 November 2012

## DEDICATION

I would like to dedicate this study to my family, sisters, brother, friends, colleagues, and to all those who teamed up in support throughout this research. To my profoundly articulate and talented maverick of a supervisor and friend, Prof. Mellet Moll, you inspired and gave me a new map to chart through life with and for that I truly thank you. Lastly to my dearest friend, who through my dire strait remained constant, I salute you.

I will forever reminisce on this journey. Thank you for your faith and support.

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# ABSTRACT

**TITLE:** An investigation of industry expectations on industrial engineering graduates: A case study of graduate development programmes in South African universities.

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**KEYWORDS:** Industry expectations, industrial engineering graduates, skills level, quality improvement, graduate development programmes, South African universities, employability.

*"The goal of university research is the creation, dissemination, and preservation of knowledge."* - Steven E. Hyman, Provost of Harvard University, 2001–2011.

Post apartheid South Africa experienced major economic turbulence with poverty, unemployment and skills shortage, with most manufacturing and other key economic sectors affected by poor productivity and a subsequent downsizing of their labour work force. At the same time, many economic opportunities arose, including the full impact of globalisation, the emergence of China and Africa as economic partners and becoming a full member of the Brazil, Russia, India, China and South Africa (BRICS) economic development group by the year 2010. The government and business communities at large realised the necessity for skills augmentation in order to expedite economic development and alleviate the scarcity of employment opportunities and growth across the major economic sectors.

The backdrop of the economic upheaval of 2008 and 2009 placed manufacturing firms under pressure to reconsider their current operational strategies by streamlining their organisations and adopting aggressive lean and cost saving approaches in order to

remain competitive. There is a perceived lack of alignment between industry and institutions alike, sometimes resulting in a perception that graduating industrial engineers do not entirely match industry expectations. Thus, it is imperative to explore the articulation and relationship between those industries that rely on the skills of industrial engineering technologists and the graduate industrial engineers with emphasis on the skills expectations as stressed by the national priorities and the academic capacity to meet these skills expectation in today's competitive professional arena. This perceived lack of alignment between end user requirements and the service provided falls within the ambit of the field of quality management.

This study focuses on two main sample groups within two areas of interest:

- The industrial engineering student community and their respective academic environments; and
- the relevant industrial engineering industry and its working environment.

A self-administered questionnaire coupled with a number of interviews is employed in order to gather the required data. Grouped samples, involve the relevant industry employers, students and academic institutions. The research explores the pertinent roles and responsibilities expected of industrial engineers and industrial engineering technologists on entry into the working environment, as compared to the current level of training offered by various institutional bodies as expressed by the South African qualifications authority (SAQA) and the national qualifications framework (NQF). The validation of the analysis and outcomes of the study culminates through the exploration of the following:

- The influence of skills levels on productivity within the relevant industrial engineering industries.
- The demand and supply of industrial engineering skills.
- Skilling industrial engineering graduates for their required roles and responsibilities.
- Governing bodies responsible for the curriculation of industrial engineering programmes, offered by institutions of higher learning.

The study aims to proffer valuable knowledge by identifying better opportunities for employment in the industrial engineering field, the addition of value towards better industrial engineering schooling and output quality of students emerging from institutions, and lastly superseding earlier misconceived perceptions of industrial engineering.

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## GLOSSARY OF TERMS

**Apartheid era:** Apartheid was a system of legal racial segregation enforced by the National Party government in South Africa between 1948 and 1994, under which the rights of the majority 'non-white' inhabitants of South Africa were curtailed and minority rule by white people was maintained (En.wikipedia.org, 1910: **O**nline).

**Business excellence:** Is the systematic use of quality management principles and tools in business management, with the goal of improving performance based on the principles of customer focus, stakeholder value, and process management (En.wikipedia.org, 2008a: **O**nline).

**Employability:** The ability to gain initial employment; hence the interest in ensuring that ‘key skills’ and an understanding about the world of work are embedded in the education system; the ability to maintain employment and make ‘transitions’ between jobs and roles within the same organisation to meet new job requirements; and the ability to obtain new employment if required, i.e. to be independent in the labour market by being willing and able to manage their own employment transitions between and within organisations (Hillage and Pollard, 1999:107,83-84).

**Exit level student:** The academic period of learning in a students’ scholarly tenure at which a student may leave the programme with recognition of learning achieved. Students who are completing their studies and preparing for industry careers (En.wikipedia.org, 2007: **O**nline).

**Graduate:** A person who has successfully completed a course of study or training, especially a person awarded an undergraduate academic degree (Allen, Fowler, and Fowler, 1990).

**Industrial engineering:** Industrial Engineering often now supplemented as Industrial & Systems Engineering or Industrial & Operations Engineering, is a branch of engineering dealing with the optimisation of complex processes or systems (Wikipedia, 2012a:**O**nline).

**Industrial engineering graduate:** An academic individual with or in the process of attaining, a recognised industrial engineering qualification from an accredited tertiary institution such as a university or university of technology for the purpose of achieve gainful employment. Their post-objectives are to exert leadership in workplace education as well as analysis, design and implementation of systems and plans for operating those systems that bring value to the organization (Wikipedia, 2012a: **O**nline).

**Industrial engineer:** A professional with a four-year minimum tertiary degree- level qualification. This type of engineer uses mathematical knowledge and natural sciences gained through study, experience, and practice, applied with judgment, to design, develop, test, and evaluate integrated systems for managing industrial production processes, including human work factors, quality control, inventory control, logistics and material flow, cost analysis, and production coordination. Industrial engineers work closely on research projects in developing new technology (The Industrial Engineering Profession, University of Pretoria, 2013: **O**nline).

**Industrial engineering technologist:** A technical engineer specialised in industrial engineering with emphasis on the application of industrial processes and personnel management and on the implementation of integrated systems dealing with problems concerning the optimal utilization of personnel, raw materials, equipment and capital in the production of goods and services including the performance of engineering and business administrative duties (En.wikipedia.org, 2013a: **O**nline).

**Industry expectation:** Means the demands and skills level required of employees by employers in industries (own source).

**Optimisation:** Means making the best or most effective use of a resource for increased productivity (Allen, Fowler, and Fowler, 1990).

**Quality improvement:** Is the actions taken throughout the organization to increase the effectiveness of activities and processes to provide added benefits to both the organization and its customers (ISO 9000:2005, 2005:9).

**Skills development:** According to the South African government, skills development is defined as 'To provide an institutional framework to devise and implement national, sector and workplace strategies to develop and improve the skills of the South African work force; to integrate those strategies within the National Qualifications Framework contemplated in the South African Qualifications Authority Act, 1995; to provide for learnerships that lead to recognised occupational qualifications; to provide financing of skills development by means of a levy-grant scheme and a National Skills Fund; to provide for and regulate employment services; and to provide for matters connected therewith' (South Africa, 2008a).

**Skills Level:** Defined as a function of the complexity and range of tasks and duties performed in an occupation; measured operationally by considering: the nature of the work performed, the level of formal education and the amount of informal on-the-job training and or previous experience (International Labour Office, 2012:11).

**South African universities:** Twenty-three public world-class higher education academic institutions offering a range of study and cutting edge research options in various academic and non-academic spheres for both local and international students (En.wikipedia.org, 2004: **O**nline).

**Syllabus:** Is an outline and summary of topics covered in an education or training course. It is descriptive unlike the prescriptive or specific curriculum (En.wikipedia.org, 2008b: **O**nline).

**System:** Is an organized, purposeful entity that consists of interrelated and interdependent elements that continually influence one another to maintain their activity and the existence of the system. The main purpose being to achieve the goal the system was intended for. (System-Wikipedia, the free encyclopaedia, 2013: **O**nline).

## LIST OF ACRONYMS

**ASGISA:** Accelerated and shared growth initiative of South Africa.

**BRICS:** Brazil, Russia, India, China and South Africa economic development group.

**DTI:** Department of Trade and Industry.

**GEAR:** Growth Employment and Redistribution.

**HESA:** Higher Education South Africa.

**I.E.:** Industrial engineering.

**JIPSA:** Joint Initiative for Priority Skills Acquisition.

**NQF:** National Qualifications Framework.

**SAQA:** South African Qualifications Authority.

**SETA:** Sector Education and Training Authority.

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# CHAPTER 1: SCOPE OF THE RESEARCH

## 1.1 BACKGROUND

Since the 1970s and 1980s, skills development was and still is a contentious issue within the work industry. Workers seeking employment opportunities and growth became redundant due to their lack of adequate skills level to justify employment opportunities, job advancements and growth. The skills shortage in South Africa has been identified as one of the main impediments to reaching the stated economic growth targets of the Government. This has advertently made skills development crucial to South Africa's growth and progress (Mlambo-Ngcuka, 2006).

Two major challenges addressed during the post apartheid era, poverty and unemployment (South Africa, 2008a), called for an aggressive approach to skills development. This aggressive approach is evident by the governments' efforts in the creation of the department of higher education and training (DHET). This has incorporated various institutional entities such as human capital development under the Human Resource Development strategy for South Africa (HRD-SA) and the higher education bodies in cooperation with the South African Qualifications Authority (SAQA) in fostering skills development aiming at realising a systemised post school education and training structure.

The South African Qualifications Authority Act (South Africa, 1995: 1; South Africa, 2008b), passed into law in October 1995. The Act prescribed the establishment of, amongst others, the South African Qualifications Authority (SAQA), the National Qualifications Framework (NQF) and the Sectoral Education and Training Authorities (SETAs). In addition, the introduction of the Joint Initiative for Priority Skills Acquisition (JIPSA) together with the higher education bodies has created a renewed approach in the economic 'skills' needs required for improving the economic growth: *"In a country such as ours where skills shortage and skills inadequacy is so glaring...There is indeed a difference between being educated in the formal sense and being productive and acquiring competencies and capabilities... The phenomenon of unemployed graduates, who* *are without abilities to self-employ and self-determine, after spending three to four years of post secondary education is an indication to all of us of the challenge in our education at a tertiary level... Universities and government have to share responsibility for this state of affairs and take corrective actions sooner...The solution lies in large part in more fundamental institutional and curriculum reform...individuals require a sound general education in order to participate effectively in increasingly complex social and economic environments... In South Africa, we have missed so many opportunities because of skills. We import artisans, welders...concurrently we also need a skills revolution in the curriculum of tertiary education, as well as in the quality of public education. Human Resource Development (HRD). The biggest crosscutting constraint. The skills that we lack and desperately need are engineering skills, planning and management skills, artisans...*" (Mlambo-Ngcuka, 2006).

The evolution of industrial engineering in South Africa as discussed by MyFundi (2012:**O**nline), began in the early 1960s with the learning 'student' being equipped with subjects like work-study, method studies, production, material handling, layout planning and a few financial subjects. During the 1970s, it was realised that the environment of industrial engineers was changing and that the student was entering the era of planning and scheduling. As a result, the academic syllabi changed accordingly, and the inclusion of additional subjects like control systems, material science, operations research, statistical quality control and computers and programming was necessary. Industrial engineers began to emerge as engineers trained to see the 'bigger picture' in a systems perspective. It was also realised that this engineer could perform outside the arena of hard production and would enter the world of the service sectors (MyFundi, n.d., 2012: **O**nline).

According to Statistics South Africa (South Africa, 2010:4.2-4.7), in 2008 and 2009, South Africa underwent a trying economic slump losing a major percentage of their manufacturing labour force. As a result, most manufacturing firms' competitive edge pegged on re- evaluating their operational strategies by undertaking leaner more aggressive cost saving approaches. This signalled a revival for the industrial engineering field as most companies delved into streamlining their organisations by employing industrial engineering practices, techniques e.g. six sigma, continuous improvement, and taking on industrial engineering professionals. Industrial engineering was slowly gaining attention as a means to cut cost and maintain a cost effective business approach. This course of events, created a niche for industrial engineering as a much-needed value-adding component for business excellence.

In contrast however, many economic opportunities arose during this time. In August of 2010, South Africa was invited to join the association of emerging national economies that included Brazil, Russia, India, China and South Africa to be known as 'BRICS', to foster economic development and growth between BRICS members (En.wikipedia.org, 2013c: **O**nline)

Industrial engineering is a necessary skill in any developing and developed country. The need is evident by the increase in the cost saving approaches South African companies are employing. With this in mind, the purpose of this study seeks to explore the correlation between industry skills expectations and the academic ability to meet this need. The study needs to satisfy the researchers' enquiry in as far as the level of graduating South African industrial engineers who are actually employed within the relevant job market and the expected growth. In addition, the needs of the job industry are ideally expected to be met by the various learning institutions i.e. universities in this case, placing responsibility on both the industry and the universities to ensure that students learn what is relevant and useful for job performance and development. In closing, it is thus imperative to investigate this relationship between industry and graduate industrial engineers with emphasis on the skills expectations as emphasised by the government and the academic capacity to meet these skills expectation in today's competitive professional arena as iterated by Nel (2010:18).

## 1.2 BACKGROUND TO THE RESEARCH PROBLEM

The role of graduate institutions facilitating the growth of human capital development in the work environment is a critical factor in South Africa, aiming at improving the productivity and economic growth of the country. In this study, the focus confines itself to three main areas for discussion:

- Academic institutions;
- students; and
- industry.

It is important to note that industry in this premise refers to the relevant industrial engineering business stakeholders. This refers to professionals working in the industrial engineering environment or individuals using industrial engineering skills to perform their duties. The research made use of professional industrial engineering and engineering bodies that comprise of members working in various business arenas as industrial engineers. These bodies are; the South African Institute for Industrial Engineers (SAIIE) and the Engineering Council of South Africa (ECSA). In this respect the research was able to cover a wider scope of the South African industrial engineering profession in industry.

The research highlights the influence the three environments have on industrial engineering skills and competencies attained by graduates.

## 1.3 STATEMENT OF THE RESEARCH PROBLEM

The research problem statement of this study is: *'There is a lack of adequate communication between industry and institutions, as a result of which, the skills level and academic qualification attained by graduating industrial engineers do not meet industry expectations.'*

## 1.4 THE RESEARCH QUESTION STATEMENT

The research question states: *"Are the industrial engineering graduates able to meet the minimum demands and skills level expected by the relevant industrial engineering industry?"*

## 1.5 INVESTIGATIVE (SUB-) QUESTIONS

The investigative sub-questions explore the relationship between the minimum level of skills and qualification expected of a graduating industrial engineer by the relevant industrial engineering companies and businesses in the South Africa by considering the following:

- What are the significant roles played by industrial engineering graduates in industry?
- What is the minimum skills level for graduate industrial engineers?
- What is the existing academic national qualification framework for industrial engineering curricula, as defined by SAQA?
- How is quality levels ensured for industrial engineering graduates in meeting industry expectations?

## 1.6 PRIMARY RESEARCH OBJECTIVES

The primary research objectives of this study are to:

- Determine the significant roles played by industrial engineering graduates in industry;
- Identify the minimum skills level of an industrial engineering graduate;
- Identify the existing academic national qualification framework for industrial engineering curricula, as defined by SAQA; and
- Define effective mechanisms to ensure high quality levels of industrial engineering graduates capable of meeting industry expectations.

## 1.7 THE RESEARCH PROCESS

The research process adopts the methodology detailed by Greener (2008), which focuses the study as a business research type that provides information to guide the management in various decision-making processes:

- Information research.
- Understanding the limitations of the research.

- Formulating a research process.
- Defining the research method.
- Sampling and Data collection.
- Data preparation and analysis.
- Data interpretation.
- Producing management guidelines or recommendations.

## 1.8 RESEARCH DESIGN AND METHODOLOGY

Case study research serves as the research method for this study. It mainly falls in the qualitative research archetype, but may also be useful within the quantitative research exemplar. According to Yin (1994:1), it may be applied in the following areas:

- Policy, political science, academic and public administration research.
- Community psychology and sociology research.
- Organisational and management studies.
- City and regional planning research.
- Research into social science, the academic disciplines, as well as professional fields such as business administration, management sciences, and social work.

Case studies essentially investigate events in its real-life context and it addresses the following: It answers 'How' and 'Why' questions, and explore events and aids the understanding thereof in a particular context. It is seen as an all-inclusive research strategy when contextual conditions are the subject of the research. This study focuses on a partial mix of four case study research methods. The four types of case studies can be identified namely as, descriptive, illustrative, experimental and explanatory case studies. Collis and Hussey (2003:68-70), states that case studies are used in areas where there is an inadequate amount of knowledge. Yin (1994:20-27), focuses on the important elements of case study research design, namely:

- Study questions.
- Study propositions.

- Unit of analysis.
- Linking data to propositions.
- Criteria for interpreting findings.

The first such method of case study method involves a descriptive case research method focusing on describing current practices in industry and academia with respect to the problem statement. The second case study approach makes use of the illustrative case study method describing current and innovative graduate programmes structures and experiential learning presently in use. Thirdly, an experimental case study method is applied in as far as exploring difficulties faced in implementing skilling of graduates under the outcome based curriculum framework in South Africa and lastly the use of explanatory case study method to explain and understand current trends in skilling industrial engineering graduates in South Africa.

## 1.9 DATA COLLECTION DESIGN AND METHODOLOGY

Data collection takes the form of survey questionnaires based on a random sampling approach. Remenyi, Williams, Money, and Swartz (2002:290), iterated that, a survey is the collection of a large quantity of evidence usually numeric, or evidence that will be converted to numbers, normally by means of a questionnaire, while questionnaires list a set of structured purposeful statements compiled to provide the researcher with reliable responses to draw from in making inferences. There are two approaches in structuring question statements namely, positivistic (structured 'closed' questions) and phenomenological (unstructured 'open-ended questions). The study of graduate attributes and qualities expected of a graduate industrial engineer at industry level may be arrived at using various means. This study made use of surveys and questionnaires as one such approach. One of the most important assumptions is the limitation that questionnaires as a survey tool are better suited to specific areas of investigation and do not allow for an in- depth analysis of the meaning of issues or phenomena (Harvey, Moon and Geall, 1997).

The questionnaire framework adopts and build upon previous approaches documented by Griesel and Parker (2009), coupled with the studies' direction and intent. The four areas Griesel and Parker (2009) detail are:

- **Basic skills and understanding:** Do graduates know and are able to compete and keep up with the work environment pace?
- **Knowledge and intellectual ability:** Are graduates able to perform well by displaying articulated rational and sufficient conceptual depth?
- **Workplace skills and applied knowledge:** Do graduates demonstrate workplace competence?
- **Interactive and personal skills:** Do graduates have a strong sense of pride and belonging?

The researcher derives the sample group from students and management staff of the Cape Peninsula University of Technology (CPUT), University of Johannesburg (UJ), University of Pretoria (UP) and Stellenbosch University (SUN), including various industry professionals and companies specifically hosting industrial engineering graduates on in- service training as well as on recent employment. The South African Institute for Industrial Engineers (SAIIE) together with the Engineering Council of South Africa (ECSA) facilitate the function representing the industrial engineering industry in the work place.

## 1.10 DATA VALIDITY AND RELIABILITY

Reliability refers to sound credible description of valid-able research outcomes achieved from repeated studies on similar areas of research. Collis and Hussey (2003:186), mentions and clarifies 'validity' as the extent to which the research findings accurately represents what is happening and whether the data is a true picture of what is being studied. Three forms of validity mentioned by Cooper and Schindler (2006:318-320), are firstly content validity, secondly criterion-related validity which is based on relevant criterion, freedom from bias, reliability and availability and lastly construct validity. Validating the reliability of the responses to question statements in questionnaires or interviews may be achieved through:

- Test re-test method.
- Split halves method.
- Internal consistency method.

### 1.11 ETHICS

Saunders, Lewis and Thornhill (2001:130), defines ethics as the "appropriateness of your behaviour in relation to the rights of those who become the subject of your work, or are affected by it." Thus the research adheres towards the following criterion:

- **Informed consent:** Participants should be afforded the right to information as pertaining the study and its nature prior to or after the study and the choice to participate or rescind involvement.
- **A right to privacy:** The participants' overall performance during the course of the study must be kept strictly confidential.
- **Integrity and professional behaviour:** The results as pertaining to the study should be credible open and candid without any unadulterated fictitious inclusions of information.
- **Confidentiality/Anonymity:** It is good research practice to offer confidentiality or anonymity, as this leads to participants giving more open and honest responses.

In order to protect from harm, this study follows the above approaches during the process of data collection. All name and identities of participated individuals and universities are kept strictly confidential. A consent form accompanying questionnaires are administered to participants for data collection.

### 1.12 RESEARCH ASSUMPTIONS

The nature of this study as described in the introduction focuses on what may be loosely termed as a 'fact finding mission'. This study builds on existing knowledge in order to enrich the limited material on industrial engineering graduate attributes and their related industry expectations. A clear distinction needs mentioning concerning the scope of this study, in that it does not attempt to define solutions or limitations, as this would negate the idea of creating a knowledge base.

The study focuses only on the 'quality' of graduates produced by the public higher education institutions in South Africa with special interest on industrial engineering student graduates as perceived by employers. Thus, it is not as aggressive in identifying the needs of the economy and the labour market as far as the totality of the nature of industrial engineering is concerned. The nature of identifying the needs of the economy in addition, the labour market is a highly complex process, which goes beyond the scope of this report.

## 1.13 RESEARCH CONSTRAINTS

The following constraints apply to the research:

- The sample group under study may not make working hours and study periods available, since accessibility of persons of interest pertinent to the study may be constrained by the nature of conditions in their environment.
- The research is limited to industrial engineers and industrial engineering graduates in South Africa.
- Research documentation on industrial engineering and related fields of study especially areas concerning academia and skills acquisition may be relatively limited.
- Under the two sample groups, the various definitions and interpretations surrounding the broad dynamics of industrial engineering may be ambiguous.

## 1.14 SIGNIFICANCE OF THE RESEARCH

There is a dual value gained by the undertaking of this research. Firstly the addition of the skills level 'knowledge base' in the industrial engineering academic programme and secondly the enrichment of the industrial engineering skills base from the perspective of the employer. Remenyi et al (2002:39) distinguishes between two sets of value derived from research studies: 'exchange' and ‘use’ value. Described respectively, knowledge building value type exists in fact finding research environments while practical gain value type is distinguished by the gain in terms of, for example monetary value from the research study. In this respect, the significance of this study is the earned exchange value to the existing knowledge of industrial engineering skills set and academic subject curriculum, contributing in turn to achieving value by creating opportunity towards gainful employment for graduating industrial engineers.

## 1.15 CHAPTER AND CONTENT ANALYSIS

The following chapter and content analysis is applicable to the research study:

**Chapter 1 - Scope of the research:** This chapter discussed the background of the study defining industrial engineering and highlighting the trends of industrial engineering as an academic discipline and industry profession. A brief introduction into the circumstances that led to the formulation and legislation of the outcome based South African higher educational framework is also dealt with rather lightly since the study does not focus on studying the technicalities of the framework but rather the link existing with industrial engineering in as far as the qualification accreditation. The definition of the research design and methodology including its logical undertaking and assumptions is included in this chapter.

**Chapter 2 - Research environment:** This chapter will form the basis of the scope of investigation falling under two main categories, one the academic environment and two the industry environment. The academic environment will revolve around defining and understanding the nature of industrial engineering as far as the academic surroundings, accreditation, attributes, to mention a few. The industry environment entails job surroundings, work ethics and culture, and roles and responsibilities of industrial engineering.

**Chapter 3 – Literature review:** In this chapter, an in depth literature review will be inducted on the relationship between industrial engineering, its expected roles and responsibilities and its academic component necessary to gain employment in the industry.

**Chapter 4 - Research design and methodology:** In this chapter, the researcher intends to define the survey environment and the boundary lines emphasizing on the data collection and sample size intended. The researcher shall define the measurement parameter scales, and elucidate on the questioners' design.

**Chapter 5 - Research results:** Chapter five will draw upon the results obtained from chapter four and attempt to answer the stated primary objectives highlighted in the dissertation by making inferences in alignment with the literature review in Chapter three. This chapter will attempt to attain the goal of the study in asserting the outcomes of the analysis.

**Chapter 6 – Conclusion:** The research will culminate at this point after having represented all areas pertinent to the study. This chapter will integrate the dissertation with an overview depicting the inferences of the outcomes as will be described in chapter five. The acknowledgement of this report will play a dual role, firstly with the intention of contributing towards narrowing the gap between industry expectations of industrial engineering graduates and relevant academic requirements necessary for gainful employment. Secondly, in adding value for further research in academia and industry domain.

# CHAPTER 2:  RESEARCH ENVIRONMENT

## 2.1 INTRODUCTION

*"A … serious problem with national magazine rankings is that from a research point of view, they are largely invalid. That is, they are based on institutional resources and reputational dimensions which have only minimal relevance to what we know about the impact of college on students …* ***'Within college experiences'*** *tend to count substantially more than* ***'between college characteristics'****."* —Pascarella, 2001

The research environment revolves around the following: institutions of higher learning, the business industry catering for industrial engineering graduates, and the course structure of industrial engineering.

The environment in question is limited within the borders of South African. In order to represent the major industrial engineering feeder universities, the study focuses on two academic universities and two universities of technology. The institutions' selection is apparent in the schools' historic and significant contributions to the industrial engineering field, skills pool in the business market and their role in the employment level of engineers in South Africa.

The following represents the sample group of institutions referred to above:

- Stellenbosch University (academic university),
- University of Pretoria (academic university),
- University of Johannesburg (university of technology) and
- Cape Peninsula University of Technology (university of technology).

Emphasis is placed on understanding the quality aspect of industrial engineering as a means towards optimum productivity, both at institutional level and at industry level and in determining how this quality aspect is and should be delivered in as far as, industrial engineering as a learned skill is concerned.

## 2.2 WORK ENVIRONMENT

As mentioned briefly in Chapter one, South Africa's economy deteriorated between the year 2008 and 2009 (as in the case of the rest of the world) with a number of key sectors, manufacturing included, amputating a significant proportion of its labour work force (South Africa, 2010:4.2 - 4.7). The volatility and erratic behaviour experienced in the economic market, resulted in uncertainties causing costly losses because of poor production forecasts. Coupled with this was the inability to manage available resources in a timely manner contributing heavily to waste in manufacturing of goods and services (Chikumba, 2009:30-39). With this in mind, industrial engineering needs to position itself strategically to effectively manage the utilisation of production factors for industrial sectors throughout the lifecycle curve.

According to the Industrial Engineering Handbook by Maynard H.B. (Zandin, 2001:1.11), Industrial Engineering is "concerned with the design, improvement, and installation of integrated systems of people, materials, information, equipment, and energy. It draws upon specialised knowledge and skill in the mathematical, physical, and social sciences, together with the principles and methods of engineering analysis and design to specify, predict, and evaluate the results to be obtained from such systems." Because all organisations behave as a system would, their main purpose is to grow their net capital by effectively achieving certain optimum outputs as defined by productivity. Achieving this desired optimum productivity level in industrial engineering requires the application of the correct resources effectively and in the right manner i.e. efficiently (Zandin, 2001:1.11).

It is crucial to determine the necessary skills required of industrial engineering graduates from a working perspective. Various roles apply to various types of industrial engineers from professional engineers, technologists to technicians all of whom full fill certain pertinent gaps in the industrial engineering field. A study of the industry from the perspective of various industrial engineering and engineering governing bodies has been conducted to develop a knowledge base on the roles expected of industrial engineers in general. The following bodies mentioned are;

- Southern African Institute for Industrial Engineering (SAIIE) and
- Engineering Council of South Africa (ECSA).

The Southern African Institute for Industrial Engineering (SAIIE) was established to foster the growth of the industrial engineering professions, achieved through initiating a learned society representing industrial engineers and industrial engineering technologists throughout Southern Africa. It aims to maintain and expedite the level of economic growth in Southern Africa through new knowledge, innovation and dynamic thinking processes (SAIIE, 2013: **O**nline)

The Engineering Council of South Africa (ECSA) was first established in the 1940s and later emerged into a statutory body recognized in terms of the engineering profession act, (South Africa, 2000). ECSA in conjunction with the South African government and the engineering profession is mandated with fostering quality education and training of individuals in the engineering profession and further full recognition of professionalism in the engineering profession, both locally and abroad. Through a voluntary network of professional engineers spread across various professional disciplines, governed by teams of its advisory committees, ECSA aims to (ECSA, 2013: **O**nline);

- Assign and monitor standards to international norms within and without South Africa,
- certify and ensure the competence of individuals through the registration of individuals and professional bodies,
- ensure quality of engineering education through accreditation of engineering skills programmes,
- regulate professional code of conduct and ethics and
- nature and develop the profession in quantity and quality in partnership with relevant stakeholders.

The above professional industrial engineering and engineering bodies is comprised of members working in various business arenas as industrial engineers. In this respect the research was able to cover a wider scope of the South African industrial engineering profession in industry.

## 2.3 INSTITUTION ENVIRONMENT

In South Africa, industrial engineering is a study programme designed under the NQF to meet the work place purpose and skill necessary for employability and productivity. The alignment of the learning tasks and the course outcome of the programme are important in ensuring productive graduates (SAQA, 2012: **O**nline).

In recent years, industrial engineering is slowly gaining attention as a means to cut costs and maintain a cost effective business approach. It has thus become necessary to explore the relationship between the industrial engineering industry and the graduate industrial engineer with emphasis on the skills expectations as emphasized by the government and the academic capacity to meet these skills expectation in today’s competitive professional arena (Nel, 2010: 18).

The study explores the definition of an active dialogue between industry and the academic community. The approach examines the correlation or a lack thereof between strategic management versus industrial engineering roles in organisations coupled with properly aligned training programmes, to ensure industrial engineering graduates and professionals alike make the greatest impact on organisational performance (Chikumba, 2009:30-39).

Following the four identified learning institutions described previously i.e. Stellenbosch University, University of Pretoria, University of Johannesburg and the Cape Peninsula University of Technology; a matrix comparison chart is used to gauge how well industrial engineering is behaving within the working and learning environment. This chart, viewed in Chapter 3 figure 3.1, attempts to answer the quality and delivery of industrial engineering as a skill for effective and efficient productivity (Moll, 1998:54-55).

The research undertakes to identify the process followed by the academic industry in developing productive industrial engineering;

- Subject requirements,
- link between industry roles and subjects delivered at institutional levels,
- level of skilled or unskilled trainers in industrial engineering learning institutions,
- scope for relevant industrial engineering teaching material,
- expected qualification outcomes and unit standards as viewed from the South African Qualifications Authority and
- the dynamics surrounding the sourcing of students into the industrial engineering course.

## 2.4 THE INDUSTRIAL ENGINEERING PROGRAMME IN SOUTH AFRICAN INSTITUTIONS

Industrial engineering focuses on the following areas of business; efficiency, or, more precisely, how to design, organise, implement and operate the basic factors of production (materials, equipment, people, information, and energy) in the most efficient manner possible. The typical focus is on optimising industrial manufacturing operations, although the skills learned are applicable to other non-manufacturing settings (Zandin, 2001:1.11).

Zandin (2001:1.11), further mentions that the primary areas where industrial engineering favours to specialize in but is not limited to fall under the following specialisations:

- Ergonomics / human factors engineering (designing the workplace to better accommodate “human factors” (human abilities and behaviours’), thereby yielding more efficient operations and fewer accidents or injuries).
- Facility design (aimed at operational efficiency).
- Applied statistics (using statistics and other forms of data analysis to aid in making management decisions and analysing work.).

- Manufacturing engineering (concerned with all aspects of manufacturing operations – materials, parts, equipment, facilities, labour, finished products, and delivery, among others).
- Quality control (using sampling, statistical analysis and other techniques to assess and maintain the quality of products or services provided by a business or other organisation).
- Work design (defining jobs that individual workers do in performing the overall work of the organisation, with the typical focus being on optimising manufacturing operations).
- Worker productivity (conducting time and motion studies, setting work performance standards, and proposing new/improved work methods).

According to the South African Qualification Authority online database (SAQA, 2012: **O**nline); an individual may obtain an industrial engineering qualification at varying national qualification framework (NQF) levels. The list below refers to industrial engineering qualifications offered at various South African institutions, arranged in a chronological ascending order:

- **National Diploma in Industrial Engineering with an NQF level 6:** One such institution offering this qualification is the Cape Peninsula University of Technology. This qualification generally entails competence in applying operations management techniques and strategies resulting in effectiveness and productivity in industry with the learner graduating as an industrial engineering technologist. The Learner expects to become knowledgeably skilled in the execution of operations management techniques in industry, application of management and leadership principles in industry, application of cost control and application of relevant principles and procedures to perform financial analyses.
- **Bachelor of Technology in Industrial Engineering with an NQF level 7:** One such institution offering this qualification is the University of Johannesburg. This qualification skills' the learner in managing of programmes concerning productivity improvement, integrated manufacturing systems, operating information systems, and project and logistics management

with the learner graduating as an industrial engineering technologist. The Learner expects to become knowledgeably skilled in the ability to apply operations management techniques in industry, provide integrated logistics support in Industry, establish, manage and maintain a small business, conceptually design integrated manufacturing systems in industry, apply research methodology in the manufacturing and service industry.

- **Master of Technology in Industrial Engineering with an NQF level 9:** One such institution offering this qualification is the University of Johannesburg. This qualification is intended to allow graduates to apply integrated operations techniques, together with advanced analysis and problem solving, to a particular specialization in the field of Industrial Engineering/Operations Management, through involvement in an applied research project. Conduct research and development in a specialised area and engage in the transfer of technology in the field of Industrial Engineering or Operations Management. The Learner expects to become knowledgeably skilled in displaying proficiency in the theory and application of research methodology, engage in original research by problem formulation, gathering and analysing information and decision-making and publish research materials.
- **Doctor of Technology in Industrial Engineering with an NQF level 10:** One such institution offering this qualification is the Durban University of Technology. This qualification is intended to allow graduates to increase the width and depth of knowledge in Industrial Engineering and Operations Management through involvement in an original research project. Conduct research and development in a specialised area and engage in the transfer of technology in the field of Industrial Engineering or Operations Management. The Learner expects to become knowledgeably skilled in displaying proficiency in the theory and application of research methodology, engage in original research by problem formulation, gathering and analysing information and decision-making and publish research material. Work effectively with and within human and industrial resources towards development and communicate effectively.

- **Bachelor of Engineering in Industrial Engineering with an NQF level 8:** One such institution offering this qualification is the University of Pretoria. The provision of a graduate-level qualification of specific knowledge and applied competence in industrial engineering in the context of the specific needs of the South African manufacturing and service industries. The Learner expects to become knowledgeably skilled in engineering problem solving, application of knowledge of mathematics and sciences, perform creative, procedural and non-procedural design and synthesis of components, systems, works, products or processes, investigation, experimentation and data analysis, use engineering methods, skills, tools and information technology, communicate effectively in professional and in general terms, understand and appreciate the impact of engineering activity on society and the environment, work effectively as an individual, in teams and in multidisciplinary environments showing leadership and performing critical functions, engage in lifelong learning through well developed learning skills and act professionally and ethically. The learner graduates as an industrial engineering professional.
- **Master of Engineering Science: Engineering Management with an NQF level 9:** One such institution offering this qualification is University of Stellenbosch. This qualification intends to provide learners with the ability to assess, plan, implement and maintain management enterprises within a technical environment. On completion of this qualification, the student is expected to have a sound understanding of the basic concepts of engineering management, design and application of engineering management processes and be able to masterfully apply engineering management techniques. In addition, the student is expected to be well-informed and be able to apply strategic management and operations management concepts within technical organisations, as well as a mastery of the mathematical, statistical and quantitative techniques applicable to solving management issues.
- **Doctor of Engineering with an NQF level 10:** One such institution offering this qualification is the University of Stellenbosch. This qualification aims to recognise critical insights, maturity of judgement, industrial proficiency and exceptional intellectual input in a specialised field of engineering. The focus

aims to habilitate students as members of the global community of scholars able to facilitate the universal pursuit and growth of knowledge in advancing the frontiers of science. The doctorate-engineering student is seen as a lead expert in the chosen field of study with an in depth understanding of the complexity of the problems involved; cognisance of the latest developments on the international research scene as far as the specific subjects are concerned. He / she must have an expert understanding of the relevance and applicability of proposed solutions. The student must have intellectual independence in contributing extensively to original knowledge in engineering field demonstrating a mature and sound judgement that is accountable and accurately represents the assessment of the views of others coupled with sound reasoning within unknown / uncharted areas of the knowledge base. He / she must be able to select appropriate tools and research methods with confidence showing the ability to synthesise and evaluate information autonomously based on independently generated criteria to design and manage complex systems effectively while working constructively in a group and in a leadership role when needed. The student must demonstrate the ability to communicate fully and professionally with high levels of self-reflexivity and adaptability with other colleagues, rising above personal prejudice and narrow-minded perceptions. Above all the student must be of high professional standing with self defined ethics, academic integrity and dedication to the ideals of scholarship.

## 2.5 CONCLUSION

Two important overviews are presented to the reader in this chapter. Firstly, it is explained what the research environment entails and secondly, it is explained where the research environment takes place. The study commences at the various institutions described i.e. Stellenbosch University, University of Pretoria, University of Johannesburg and the Cape Peninsula University of Technology including the two governing bodies SAIIE and ECSA as mentioned in this chapter. The study begins by addressing the various institutions current academic *modus operandi* and the business industries' job structures and working requirements through the engineering governing bodies as described in paragraph 2.1 and 2.2.

Since a thorough understanding of the current affairs of the field is imperative, Chapter 3 of this study speaks to the existing knowledge behind the industrial engineering's academic components including its industry skills requirements. The chapter also addresses the quality aspect related to the skill of industrial engineering and how this impacts the level of performance both in industry and in academia.

# CHAPTER 3: LITERATURE REVIEW

## 3.1 INTRODUCTION

*'Scientists investigate that which already is; Engineers create that which has never been.'* (Albert Einstein)

The industrial engineering a programme is offered globally in institutions of higher learning. These institutions strive to create innovative current and knowledge driven engineering programmes that have considerably industry value. This value not only influences economic growth but plays a significant role in increasing the level of throughput within respective academic institutions (Heitor, 2008).

According to ISO 9000:2005 (2005), value and quality have a relative relationship. Quality as shall be seen in more detail in the following pages may be defined as something that can be determined by comparing a number of intrinsic features or characteristics within a product or a service with a set of requirements. If those intrinsic characteristics meet all the requirements, high or exceptional quality in this case 'value' is achieved.

Looking at value and quality as significant, the research focuses on the following key areas in the literature review:

- The concept of quality and its significance in industrial engineering,
- skills level and its impact on productivity, highlighting the question of value of industrial engineering and
- the expectations of industrial engineering graduates and the role played by the regulating bodies of higher learning institutions to foster this value.

## 3.2 QUALITY

Green (1994) cited by Newton (2006), suggests that the best that can be achieved in defining quality, is to describe it as clearly as possible in as far as, the criteria that each stakeholder uses when judging quality and for these competing views to be taken into account when assessments of quality are undertaken. Foster (2001:5) citing Garvin (1984) goes on to describes the various forms of quality as understood by various stakeholders within the organisation. These forms of quality are transcendent, product-based, user-based, manufacturing-based and value-based. Newton (2006) Iterated further, that a pragmatic view of quality may describe quality as stakeholder-relative with varying perspectives viewed by different interest groups with different priorities. Within the confines of this research, these points of view of quality and their relevant stakeholders are as follows:

- Students and teachers may view quality as the process of education;
- Industry stakeholders and employers may look at quality from the outputs of higher education perspective.

(Harvey and Green, 1993; Harvey, 2006; Harvey and Knight, 1996), further hold this to be true in their categorisation of quality into five categories:

- **Quality as exceptional or as excellence:** Benchmarking approaches and quality assurance through external examiners, accreditation, and regular set audits.
- **Quality as perfection or consistency:** The measure of academic administrative processes and mechanisms that deliver the services.
- **Quality as fitness for purpose:** Attaining university purpose and goals. Quality assurance bodies such as the Engineering Council of South Africa (ECSA) may assess this.
- **Quality as value for money:** Meeting the institutions stakeholder’s needs against costs incurred. Assessing performance data such as student retention, completion, and employment among others.
- **Quality as transformation:** Development and empowerment of student and staff through learning process like teaching and learning programmes.

### 3.2.1 Quality in industrial engineering education

Describing quality in industrial engineering as existing within two distinct paradigms, the first describing it as being the perceived value of the programme and the second being the characteristics within the industrial engineering skill, as being relatively synonymous to the delivery process of quality as commonly applied in any system. Institutions of higher learning offering industrial engineering have to consider the effectiveness of the programme in offering value, efficiently, within its application areas based on the expected industry requirements. Simultaneously, industrial engineering, from its techniques and approaches to problem solving, design improvements and strategic planning among others, mimics and mirrors similar approaches quality has in optimising throughput, reducing waste, achieving customer satisfaction, in addition to others within organisations. Just as any other organisation that utilises quality to gain optimum throughput, higher education requires a quality component. Viewing industrial engineering in institutions of higher learning as a system with interrelated components, with the 'customer' being the product of interest such as the graduate industrial engineer, quality becomes an aspect that is difficult to ignore just as in any other manufacturing process (Moll, 1998:78-85).

Chikumba (2009:33), in his discussion on industrial engineers and the organisational transformation model, emphasises that understanding organisations as a model is important for successful execution of corporate strategy and that viewing the organisation as a transformation process, which satisfies customer needs, through maximizing value added to inputs producing outputs through routine and repetitive or programmable decisions is important. In adding this value, the dimensions of quality should not be ignored in value creation; value accrues through the creation of the products' function. In this case, value may be enhanced primarily through the management of these dimensions. A few of these many dimensions are; responsiveness, performance, reliability, conformance, durability, serviceability, aesthetics, and perception among others.

A cartesian matrix may be useful in describing relationships between different variables. The need for industrial engineering to meet student needs, while achieving customer industry requirements can be illustrated in the relationship between effectiveness and efficiency through an X and Y-axis as show in the model below:

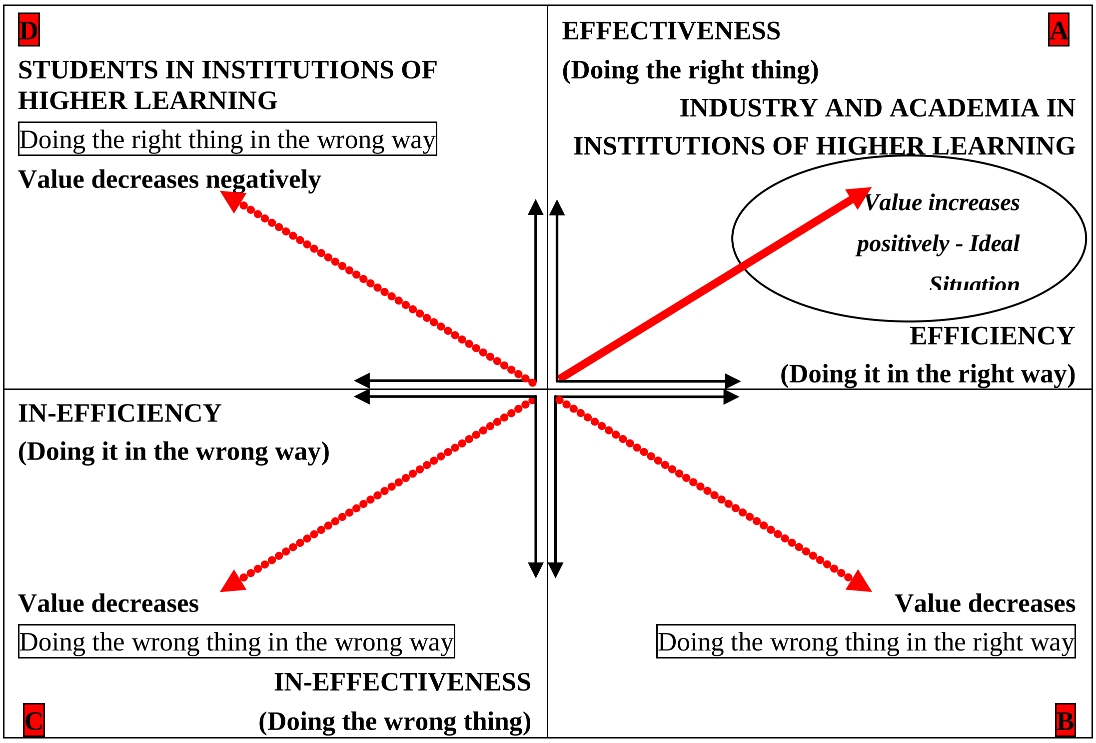


**Figure 3.1:** Efficiency and Effectiveness:-Value (O'Sullivan, K., 2008:233)

Leonard, Kruger, and Moll, (2006: 2) discuss organisational behaviour by making use of the relationship between effectiveness and efficiency in the hierarchy of basic needs of an organisation model. According to Dictionary.reference.com (2012: **O**nline) and O'Sullivan, K. (2008:233), being effective is defined as 'adequate to accomplish a purpose; producing the intended or expected result.' Being efficient on the other hand is performing or functioning in the best possible manner within the shortest time possible and with the least amount of effort.' In this context and on the model depicted above, effectiveness is describes as doing the right task (things), right being the prominent word and efficiency denoted as how well one performs that task (things), thus the phrase 'doing the right thing in the right way'. This phrase would refer to an ideal situation as depicted in quadrant 'A' in figure 3.1, where effectiveness increases on the Y-axis and a simultaneously increase in efficiency occurs on the X-axis projecting a 'value line' (Moll, 1998:54-55).

Therefore, from the model above, effectiveness and efficiency of doing 'things', appears in the four quadrants (A, B, C, D) shown in the model above, giving the reader a perspective of different behavioural possibilities within various environments. This study identifies three such environments i.e. the institution of higher learning, the Industry and the Student community. These environments may be depicted as behaving within the various quadrants, allowing the reader to better understand the circumstances surrounding the argument of the gap between industry expectations of students and the ability of students to meet this need.

As previously mentioned, looking at industrial engineering in institutions of higher learning as a system with interrelated components, with the 'customer' being the product of interest such as the graduate industrial engineer, quality becomes an aspect that is difficult to ignore. Value is, in this case, considered as a 'product – student / industry', derived from the effective deployment of activities in an efficient manner and may be described further through a mathematical formula as shown below (Sink and Das, 1986:42):

$$VALUE = \frac{\text{FUNCTIONALITY (as a Product or Service or System)}}{\text{COST}}$$

$$\therefore VALUE = \frac{\text{QUALITY, SPEED, and FLEXIBILITY (Drivers of value)}}{\text{RISK, WASTE, and CASH FLOW (Drivers of value)}}$$

**Figure 3.2:** Operational value drivers (Moll, 1998:322)

Moll (1998: 43-45, 305-315) discusses the value formulae in figure 3.2 terming it as the 'operational value drivers' derived as the ratio of performance or function (output) vs. cost (input). The magnitude of value is thus determined by a change in the two variables functionality and cost. A positive magnitude is denoted as a result of an increase in the functionality of the product / service with a subsequent decrease in the cost input variable influencing a positive value change. He further iterates the factors that influence this value as, quality, speed, flexibility, risk, waste and cash flow identical to the dimensions of quality i.e. quality, speed, flexibility, expenditure, risk and waste.

Burrowing deeper into relationships between effectiveness and quality, Ho and Wearn (1996:35-36) citing ISO 9004-4:1993 (1993), define Total Quality Management (TQM) as a management philosophy and company practices which aim to harness the human and material resources of an organisation in the most effective way to achieve the objectives of the organisation. Ho and Wearn (1996:37) refer to the principles and tools surrounding total quality management as one way of managing institutions that provide industrial engineering as a programme to improve the effectiveness, efficiency, cohesiveness, flexibility, and competitiveness of the programme.

Ho and Wearn (1996:36-37), further state that while higher education institutions are the home for learning and creating knowledge through their research function, it is ironic that they have been lagging behind other organisations in embracing and implementing TQM. This inertia in the adoption of TQM seems to be due to certain structural and traditional characteristics of higher education institutions. Eagle and Brennan (2007:45), interpret the concept ‘student as customer’ as a derivative from the TQM movement in the manufacturing industry, due to its motorized consistent production emphasis built in the movement. However, as sensible and logical as this may be, it caused discomposure in the education industry thus was not popularised (Lagrosen et al., 2004; and Eagle and Brennan, 2007:45). The need and importance to apply TQM in the development of strategic outcomes within the higher education environment should be apparent in order to offer quality industrial engineering programmes able to deliver excellence in the industry and contribute towards economic growth.

### 3.2.2 The application of the principles of TQM to industrial engineering

Total quality management (TQM) is a philosophical management approach developed by several management professionals one of whom was the quality guru W. Edward Deming through his fourteen points on how to implement quality improvement. Organisations use TQM to implement quality policies and objectives through directing and controlling a set of integrated elements in order to achieve a high level of overall operational excellence. Deming's fourteen points were developed further into seven effective concepts namely, continuous improvement, six sigma, employee empowerment, bench marking, just in time (JIT), taguchi concepts, and the knowledge of the TQM tools (En.wikipedia.org, 2013b: **O**nline).

According to Anninos (2007:315), management in total quality is people oriented focusing on an individual and collective contribution in continuously lowering costs by learning and adaptation to change. Lagrosen and Lagrosen (2006:85) and Evans and Lindsay (1999) describe the principles of TQM that characterize a quality-centred university as developed by W. Edward Deming through his fourteen points of effective quality management, as:

- Realizing, conceptualising, and developing the needs and expectations of the stakeholders in institutions of higher learning.
- Demonstrating leadership commitment through the development of customer-oriented goals, objectives and expected outcomes of key stakeholders within the teaching environment. Encouraging involvement, teamwork and setting a culture of excellence.
- Staff development and support through teaching and learning.
- Process oriented focus by accurately defining the needs into industry-realized outcomes to build quality into services.
- Management and control of education process through productive performance measures.
- Continuous improvement and learning.

During the first half of the 20th century, (Taylor, Fayol, Weber, Mintzberg, among others.) developed various management ideologies that revolved around efficiency, organisational structures, productivity, managerial responsibilities, work division and the management principles. Furthermore, at the time, the management roles overlooked the crucial dynamics of the psychological and social needs of the organisations stakeholders. Building on this scientific decision making process developed by (Taylor, Fayol, and Weber, among others), industrial engineering developed through the implementation of time and motion studies, standardization, objectives setting, incentives, employee training and selection and in the contributions by Mayo, Herzberg and Maslow among others, in understanding the social dimension of work by combining the operational/technical and human dimension of organisations. Therefore, re-constituting quality in industrial engineering perspective, according to this school of thought, excellence as a total quality management theme meant stressing on the human element and the inspiration of workers by aligning their needs with the organisation of work. This new perspective on management brought about the realization that problems experienced within the organisation were becoming too complex to manage and forced the management to rethink their approach to problem solving. A new outlook of the organisation was necessary, that would take into account all dimensions and consequences of a problem and the results of a suggested solution in every department/division of the organisation (Daft, 2006:37-50).

This new perspective took the form of what is termed as a ‘System’, a holistic look at the organisation as a group of interconnected parts that form a whole and together working towards a common purpose. This approach attempts to solve the problems related to the combination of structures and human behaviour. Figure 3.3 represents a simple diagrammatic representation of this. Additionally, the figure depicts the typical players that exist within a ‘system’ and when a logical manipulation of the players and the process is applied, optimisation and increased productivity is realized (Zandin, 2001:1.11).

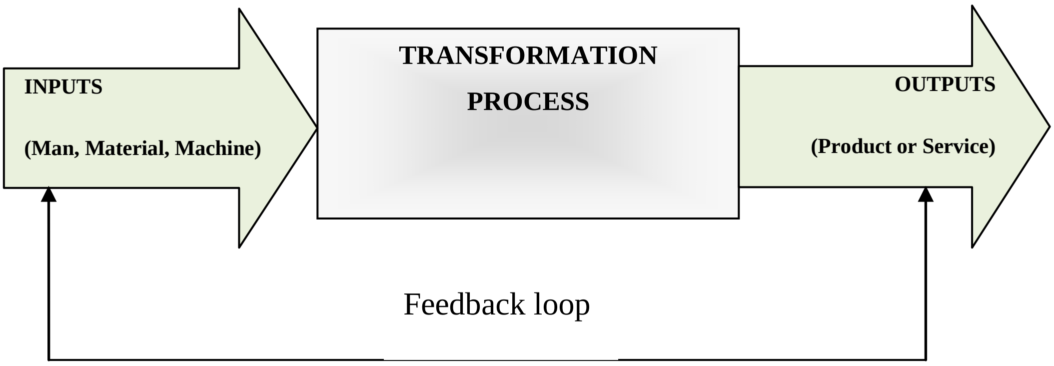


**Figure 3.3:** 'System' with a feedback loop (Source: Zandin, 2001:1.11)

As such, industrial engineering and quality are synonymous in their approach to effective use of tools and techniques towards optimum productivity by executing the practices involved efficiently in dealing with the dynamic components in a system (Zandin, 2001:1.11).

## 3.3 SKILLS LEVEL AND ITS' IMPACT ON PRODUCTIVITY

Since 1994, the skills shortage in South Africa has been of concern triggering various discussions forum in an effort to understand and articulate its dynamics and impact towards economic development. The 2011 national development plan highlights employment and skills shortage as a key challenge towards socio-economic growth and development (South Africa, 2011a:3). Studies suggest that skill scarcity has an interrelationship with the prevailing poverty, unemployment and educational development in South Africa (South Africa, 2008a).

### 3.3.1 The impact of skills level on productivity

South Africa (2009a) describes the extensive national development initiatives like Growth Employment and Redistribution (GEAR), Accelerated and Shared Growth Initiative for South Africa (ASGISA) and the Joint Initiative on Priority Skills Acquisition (JIPSA) that have been consecutively documented trying to tackle this skills shortage. One such initiative Resource Development Strategy for South Africa (HRD-SA) advocates for the provision of skills to expedite economic and social development. The National Planning Commission, highlighted the importance of educational outcomes as being one of the challenges faced by South

Africa (South Africa, 2011b). Poverty, inequality and unemployment are continuously under debate with skills scarcity being topical (South Africa, 2011b:7). Iterating further, South Africa (2009c), describes the gap between income inequalities in the various sectors of industry in South Africa plays a major role in the skills shortage arena. Results obtained from the 2005/6 Income and Expenditure survey, show a resounding gap between income earners in industry. Despite ten percent of the population earning more than fifty percent of household income, eighty percent of this population earns less than eight and a half percent of the household income, negating the need for skills as a source of income (South Africa, 2008c). In addition, the unusually high unemployment rate manifests itself with a low youth count in the labour market and the education and training system (Cloete, 2009:3-13). The poor and ineffective educational outcome is evident in the poor results seen in the current Annual National Assessments literacy and numeracy levels (South Africa, 2011c).

This challenge, calls for a more effective approach towards the education system and balance between labour supply and demand if there is to be an improvement in the socio-economic growth and development. Articulation of the link between the education sector and industry creates a platform for development of quality programmes in the education sector that caters directly for the needs of industry (South Africa, 2007d:41 and 2011d:16). The department of trade and industry (DTI) iterates this in the National Industrial and Policy Framework (NIPF) stating that '...the skills and education system form a fundamental pillar for the success of an industrial policy. There is currently insufficient integration between industrial policy objectives and skills in the education system. There is therefore a need for a much closer alignment between industrial policy skills and education development, particularly with respect to sector strategies...' (South Africa, 2009b:43). In light of these revelations of inequality and poor pre-schooling outcomes, an understanding of the importance of effective post schooling and supporting training systems is worth exploring in order to improve South Africa's developmental growth and sustainability.

## 3.4 INDUSTRIAL ENGINEERING; ITS VALUE TO INDUSTRY

### 3.4.1 Industrial engineering vs. demand

Industrial engineering is a branch of engineering that focuses skills knowledge geared towards effective systems development and optimisation in both product engineering and service related fields (MyFundi. n.d., 2012:**O**nline). In the South African engineering context, industrial engineering is a skill viewed in various forms such as industrial technologists, industrial technicians and industrial professional engineers (South Africa, 2007b:16 and South Africa, 2007a:47).

Defining the labour market as conforming to supply and demand of the labour market, unemployment inequalities and labour absorption in South Africa according to Erasmus, Loedolff, Mda, and Nel (2006:264) is an area that has lagged demand for the engineering industry over the years (Kochanski and Ledford, 2001:32). The rise in the demand for industrial engineers in South Africa has been marginal at best, demonstrated by its incremental rate of incline since 2006 (Nel and Mulaba-Bafubiandi, 2009:930). This is an indication as to the limited awareness industrial engineering has received in South Africa, given its existence as a global profession since the 1940s. The department for Home Affairs listed industrial engineering as a national scarce and critical skill in 2006 substantiating the need for industrial engineering as a highly sort after skill (South Africa, 2009b:4). According to Nel and Mulaba-Bafubiandi (2009:930), the current number of professionally registered South African engineers in the engineering database since 2006, was five thousand for engineers, one thousand six hundred for technologists, six thousand seven hundred for technicians and as of March 2005 only two hundred and twenty five registered industrial engineers.

A 2008 statement by the Southern African Institute for Industrial Engineering (SAIIE) iterated that the varied characteristic of the industrial engineering profession has resulted in the fragmentation of the discipline. The discipline has shifted beyond the conventional engineering applied in the manufacturing sector prior to 1950, threatening the sustainability of the industrial engineering profession. Furthermore; its breadth of practice has widened to feature in non-manufacturing areas, which include consulting, banking, healthcare, and government. (Nel and Mulaba-Bafubiandi, 2009:930).

In 2005, the SAIIE submitted data that suggested that in excess of sixty percent of industrial engineers worldwide were in the non-manufacturing industry. To substantiate this, SAIIE has two hundred and fifty established members, in comparison to eight thousand active affiliates in the South African Institute for Civil Engineers. Additionally, a number of its potential members would rather enrol with discipline specific organisations such as the Supply Chain Management Association including among others, the Operations Research Society of South Africa (Nel and Mulaba-Bafubiandi, 2009:930).

Nel and Mulaba-Bafubiandi (2009), further states that in 2005, of the two thousand South African registered learners pursuing National Diplomas in industrial engineering, only Five hundred to six hundred did successfully graduate. Subsequently, only a third of the students gained entry into the professional field, owing to poor academic performance and inexperience caused by a lack of sufficient engineering practice learner-ships such as in-service training. This only contributed to one percent of the total number of industrial engineers recorded in 2005. Nel and Mulaba-Bafubiandi (2009) confirm this by referencing an article in The Business Times of March 2007. The article, cited in Project2010 (2007,nd:**O**nline), stated "…companies are buckling under the increasing demands of a growing economy and in the face of fierce competition from international businesses, companies 'creaking under the strain' of a 'skills crisis' and the need to deliver bigger volumes of goods to increasingly diverse customers. This is compromising SA's global competitiveness and is spurring 'poorer' service across various industries"..."due to the shortage of skills in engineering, supply chain management, warehousing and distribution, and network analysts..." all skills relevant to industrial engineering (Project2010, 2007,nd:**O**nline). In addition, the discussion forum held by the SAIIE industry forum in 2008 estimates that about one thousand industrial engineers are needed every year in order to meet this level of industrial engineering demand for South Africa.

## 3.5 INDUSTRY EXPECTATIONS OF A GRADUATE INDUSTRIAL ENGINEER

The purposes and scope of industrial engineering have widened considerably. The challenge to meet the changing world when it comes to globalisation, modernization, automation, and the growth of systems has moved industrial engineering from the conventional manufacturing industry into all sectors of the economy, including services, utilities and the higher sectors of the value chain. It is thus up to the industrial engineering community to uncover innovative ways to respond to the challenges while ensuring the integrity of the core character of industrial engineering in order to thrive and be sustainable in meeting future needs (SAIIE, 2008).

Two areas of concern may arise; one is in the way in which industrial engineers are to be trained and secondly industrial engineering becoming diluted. Boundaries between disciplines tend to disappear, as industrial engineers move into other disciplines, and practitioners of other disciplines move into industrial engineering. Furthermore, industrial engineering suffers from what some call an ‘identity crisis’. The question being, are what industrial engineers doing relevant to industry, given that they are multi faceted? To call one-self an industrial engineer, what criteria does one have to comply with? Industrial engineers are systems oriented, integrating systems into a whole, whereas the other engineering professions are one disciplined, and singularly faceted (SAIIE, 2008).

Differences in the professional boundaries and roles between engineers, technicians, and artisans in industry as well as in universities and universities of technology specializing in training practitioners, are not as apparent and clear for industrial engineering as compared to other professions and disciplines. The training roles of universities and universities of technology pose a challenge in unifying and standardizing clear boundaries for industrial engineers. Industrial engineering must continuously clarify for and to other people what they do. Engineering graduates in other disciplines are performing duties and jobs that are primarily the focus of industrial engineers, partly due to there not being enough industrial engineers (Chikumba, 2009:30-39).

The role of industrial engineers in ensuring strategic growth and development for organisations and companies becomes apparent once the alignment between a company's mission and goals with its strategic planning policies is realised. Industrial engineers are then able to perform their functional roles some of which are: resource allocation, performance management systems and incentive schemes, information communication systems, best practices and continuous improvement approaches. These roles are simplified into the following disciplines: communication and team development, leadership and entrepreneurship (Chikumba, 2009:30-39).

### 3.5.1 Industry perspective: Skilling industrial engineering roles

Industrial engineering needs to position itself to manage the utilisation of production factors for industrial sectors throughout the lifecycle curve. Chikumba (2009:30-39) writes, "...the volatile economic environment is presenting firms with uncertain customer demand and variability in customer order patterns, high inventory costs and demand for mass customization therefore threatening their survival..." Similarly, in South Africa, the steady economic growth and in contrast the Inflation and rising fuel costs place companies under pressure to innovate as well as contain their costs. This presents opportunities for industrial engineers to become recognized. The tourism industry for example is on a growth pattern and the telecommunications sector is maturing at a steady rate while other industries have matured greatly and nearing the end of their life cycle curve e.g. mining. These are but among many areas, that an industrial engineer can thrive by contributing to a large scale in addressing issues such as strategies, and socio economic development concerns (SAIIE, 2008).

Complexities of wealth inequalities and the prevalent poverty crisis provide industrial engineers with possibilities for business development, product innovation and expedient market delivery systems. The test for industrial engineers in South Africa is to transcend idealistic motives and address socio-economic issues such as housing delivery and job creation by taking an overall systems view of all resources from the perspective of creating business sense, in the interests of sustainability on all fronts (SAIIE, 2008).

The achievement of these opportunities, lie in the ability to train and educate industrial engineers through gainful regimented academic course work, that will ultimately produce industrial engineering graduates, who are ethically and intellectually prepared to take up responsibilities within diverse organisations, culminating in economic sustainability. A clear correlation between strategic management versus industrial engineering roles in organisations coupled with properly aligned training programmes can ensure industrial engineering graduates and professionals alike make the greatest impact on organisational performance (Chikumba, 2009:30-39).

Globalisation has brought about continuous transformation changes in technology, organisational structures and skill development (Heizer and Render, 2011:34-52). The role of higher education is such that demand for knowledge and skills by companies should be met through the development of generic proficiencies that meet all levels of work. Companies are at odds to meet this need pushing them to pursue numerous alternative strategies for adopting skills and competencies (Luckett and Sutherland, 2000:59).

Chikumba (2009:30-39) cited six skills acquisition strategies for adopting skills and competencies used by companies, according to Padfield, Schaufelberger, Dresling, Van den Eijnde, Fernandes, Hagstrom, Meuret, Rautiainen, and Schrey-Niemenmaa (May,1998:7-25):

- Companies building specific training programmes.
- Companies establishing staff developmental plans.
- Companies recruiting staff trained on up to date core competencies by other companies.
- Companies outsourcing consulting services that are making use of current techniques and skills.

- Companies contracting with private educational entities for training needs and commission customized distance-learning programmes.
- Companies developing operational and functional staff in industrial engineering who team up to develop value based performance standards and control systems.

Citing Woollacott and Snell (2006:141-152), engineering educators grooming new industrial engineering graduates, must focus on building applicable theory complimented by the associated industry skills, both technical and soft skills, necessary to perform within actual engineering environments. A synergy of industrial engineering roles and management strategies, coupled with core competencies that correlate with the academic curriculum, will achieve the desired systemized feedback loop structured to realize continuity and excellence of future industrial engineers and the engineering discipline.

### 3.5.2 General academic requirements for industrial engineers

As mentioned severally in this study, industrial engineering bases its approach on a systems perspective of industrial business units. According to the University of Stellenbosch and the University of the Witwatersrand, industrial engineers perform duties related to business process systems, technology i.e. optimal design and people through implementation, integration, operation, improvement and management of advanced systems that make up an organisation. These systems make use of areas such as chemical, electrical, electronic, mechanical or civil. “These systems are not available as off-the- shelf items and cannot be imported or bought from a supplier”. They exist as resources that form part of the system core (University of Stellenbosch, 2007: **O**nline and University of the Witwatersrand, 2012: **O**nline).

Developing countries like South Africa are predominantly net importers of technology, emphasizing process development as opposed to product development. Industrial engineers therefore will be focusing on optimising the processing mechanisms and structure of organisations and manufacturing entities by producing and improving on output quality, quantity and value of process capabilities (Chikumba, 2009:30-39).

Industrial engineering skills are applicable at various organisational levels depending on the operational needs dictated by the organisation. According to the organisational configurations model developed by Mintzberg (1979), every organisation generally consists of six basic sections:

- Strategic Apex (top management)
- Middle Line (middle management)
- Operating Core (operations, operational processes)
- Techno structure (analysts that design systems and processes, among others)
- Support Staff (support outside of operating workflow)
- Ideology (halo of beliefs and traditions; norms, values, culture)

Fitting the various roles of industrial engineering fields, the following main categories stand out (Wikipedia 2012a: **O**nline):

- **Enterprise engineering:** This is the engineering of enterprises as a whole, which evolved from systems engineering. In order to achieve this, industrial engineers make use of their ability in the application of knowledge, principles, and disciplines related to the analysis, design, implementation and operation of all elements associated with an enterprise.
- **Systems engineering:** This is the approach to design, creation, and operation of systems. It entails the identification and quantification of system goals, with the aim of integrating the needs of each related subsystem to fit the purpose of the main system. The need arose with the increase in system complexity, due to poor subsystem integration, and subsequently unstable system reliability.
- **Operations management:** Operational industrial engineering focuses on the design and improvement of operations and activities related to the functions delivered by the system role players. One such area is in the supply-chain-management operation that aims to link the organisations role players internally and externally in the system.

- **Applied industrial engineering:** This is the application of industrial engineering in specific industries. These industries may be dictated by the national economic growth needs. In South Africa, the current industrial needs fall under production and productivity growth.
- **Engineering management:** Engineering management is a specialised form of management that is concerned with the application of engineering principles to business practice. Engineering management is a career that brings together the technological problem-solving practical understanding of engineering and the organisational, administrative, and planning abilities of management in order to oversee complex enterprises from conception to completion.

The academic studies related to industrial engineering industry disciplines includes and is not limited to Operations Management, Operations Research, Manufacturing Technology, Organisational Behaviour, Materials Science, Mechatronics, Finance and Economics, Systems and Project Engineering, Entrepreneurship and Advanced Mathematics and Statistics among others (University of the Witwatersrand, 2012:**O**nline).

Chikumba(2009:30-41) cites Wikipedia (2012:**O**nline) and highlights a few career specialization areas that have the capability an industrial engineer will need to optimise process-oriented systems and as such the industrial engineering academic requirements should fall within these specializations. These are:

- Operations Management.
- Operations research.
- Engineering management and economics.
- Supply chain management and logistics.
- Simulation and modelling.
- Manufacturing systems and engineering.
- Human factors engineering and ergonomics.
- Quality and production planning and control.
- Materials management.
- Performance management.

- Operations management.
- Problem-solver.
- Innovator.
- Coordinator.
- Change agent.

According to Chikumba (2009:30-39) and Woollacott, (2007) the industrial engineers' roles as reflected in the related academic units mentioned above may be summarized as:

- The effective execution of corporate strategies if the alignment of mission, strategies, business goals and planning methods, planning and control activities are clearly defined.
- The effective application of operational and functional activities where industrial engineers can be involved in resource allocation, developing of performance management systems and reward structures, installing information and communication systems, institution of best practices and setting foundation for continuous improvement.

## 3.6 THE HIGHER EDUCATION BODIES RESPONSIBLE FOR CURRICULATION OF INDUSTRIAL ENGINEERING

Higher education bodies responsible for curriculation of industrial engineering as a study programme, tasked with the mandate to formulate, standardize and monitor the current and emerging academic and non-academic qualifications, brought about a means to steer skills level towards a more productive focal point. These bodies are the South Africa National Qualifications (SA-NQF) Framework and the Engineering Council of South Africa (ECSA).

One body that is not included under the higher education statutory bodies but contributes immensely, by its own right, towards fostering economic growth in the business and other economic sectors, is the Southern African Institute for Industrial Engineering (SAIIE). SAIIE as the name implies, is an organisation made up of industrial engineering members from various disciplines drawing upon specialised knowledge and skills in the mathematical, physical, behavioural, economic and management sciences focused on finding optimal and practical solutions, which contribute to the success, prosperity and the creation of wealth in the Southern African economy. SAIIE aims to be a vibrant, learned society, representing and promoting all industrial engineers, while maintaining a high level of standard for all industrial engineers within Southern Africa (SAIIE, 2013: **O**nline).

### 3.6.1 The role of SA-NQF

The South Africa National Qualifications Framework (SA-NQF) is one such body, which was legislated in 1995 as a key mechanism for creating a more democratic education system. SA-NQF enabled the legislation of the South African Qualifications Authority (SAQA), a statutory body established in terms of the SAQA Act of 1995 and mandated to manage the development and implementation of the NQF. Some of SA-NQF stated objectives are (South Africa, 1995):

- To facilitate access to education and training.
- To facilitate mobility and progression within education, training, and career paths.
- To enhance the quality of education and training.
- To accelerate the redress of past unfair discrimination in education, training and employment opportunities.
- To contribute to the full personal development of each learner and the social and economic development of the nation at large.

The NQF is a set of principle and guidelines, from which a qualifications system is built. The framework is made up ten levels, see table 3.1, divided into the following three categories;

- General education and training (GET) made up of the adult basic education and training (ABET) and the compulsory schooling up to standard eight,
- further education and training (FET) and

- the higher education and training (HET).

**Table 3.1:** SA-NQF Levels (Source: South Africa, 1995)

| NQF | Description | Category |
|---|---|---|
| One | Grade 4 to 9 (Standard. 2 to 7) | GET |
| Two | Grade 10 (Standard. 8) | FET |
| Three | Grade 11 (Standard. 9) | FET |
| Four | Grade 12 (Standard. 10 / Matric) | FET |
| Five | National certificate or national diploma or occupational certificate | HET |
| Six | Bachelors degree (min. three years) or higher diploma | HET |
| Seven | Honours degree or post graduate certificate | HET |
| Eight | Doctorate or masters degree | HET |

### 3.6.2 The role of ECSA

Another such body is the Engineering Council of South Africa (ECSA) a statutory body recognized in terms of the engineering profession act, (South Africa, 2000). ECSA is mandated with, the following responsibilities. Firstly ensuring that quality education and training of the engineering profession is maintained and secondly to facilitate the full recognition of professionalism in the engineering profession. Through a voluntary network of professional engineers, ECSA aims to (ECSA, 2013: **O**nline):

- Assign and monitor standards to international norms within and without South Africa,
- certify and ensure the competence of individuals through the registration of individuals and professional bodies,
- ensure quality of engineering education through accreditation of engineering skills programmes,
- regulate professional code of conduct and ethics and
- nature and develop the profession in quantity and quality in partnership with relevant stakeholders.

### 3.6.3 The impact of accreditation on industrial engineering

"Trends in Public Higher Education in South Africa: 1995 to 2004" (South Africa, 2007c) is a report that demonstrates the quantity of learners who have successfully passed to graduate during the period 1995-2004 and the number of qualifications registered since the inception of the outcome based NQF initiative. The report defines a national higher diploma in industrial engineering as a qualification with an NQF rating of seven, which will serve as an example or basis of reference throughout this dissertation.

As mentioned previously, the outcome-based accreditation of undergraduate engineering programmes has been under discussion since the mid 1900s (Martin, Maytham, Case and Fraser, 2005). The accreditation emphasizes the need to produce graduates that adequately meet the needs of industry and as such, it is important to explore whether the outcomes of such engineering programmes do indeed match the needs of industry (Martin et al., 2005; Griesel and Parker, 2009).

It is important at this stage to clarify what qualifies as industrial engineering attributes and qualities. Martin et al. (2005); Evans, Beakley, Crouch and Yamaguchi (1993); Keenan (1993); Lang, Cruse, McVey, and McMasters (1999); Meier, Williams, and Humphreys (2000); Scott, and Yates (2002:7-26) describes the desirable attributes or competencies of an engineer as being categorized in terms of key technical, non- technical, scientific and engineering practice competencies. Meier et al. (2000); Sageev and Romanowski (2001), further iterate that the science of engineering is that set of mathematical and scientific tools used to solve engineering problems. Evans et al. (1993); Scott and Yates (2002:7-26), highlight the practice of engineering as the recognition and formulation of a problem and its solution.

According to Martin et al. (2005), the science of engineering in an engineering degree/qualification, allows one to adequately define the students competency as an engineer adding that the inclusion of open-ended design problems in the curriculum qualification, improve a student's ability in the practice of engineering skills. Martin et al. (2005), further states that these skills require long term industry experience and leave room for the possibility that graduate engineers may qualify without the skill to problem solve and cognise solutions.

Mayer (1992:13) describes in summary a commonality between initiatives carried out to identify skills seen as essential aspects of employability by the Mayer Report (Mayer,1992), the Finn Report (Finn, 1991), the Dearing Report (Dearing, 1996) and, The Secretary’s Commission on Achieving Necessary Skills (SCAN, 2000). The results notes that the skills and competencies highlighted were:

- Impartial to all subject areas, educational programme, qualification or awarding body.
- Vague to any vocational task or career path but common to both general education and vocational education and training.
- Focused on outcomes, in each case defined as precisely as possible with various levels to indicate the variety of individual attainment.

Griesel and Parker (2009) concludes by citing Harvey and Green (1994) that ‘core skills and competencies’ necessary for employability are not to be viewed as generic within graduates and thus not considered transferable because employability is skill specific and too complex to generalize in this context. Iterating further, he states that defining core competencies is not enough and requires incorporating other areas that complement the relevant skills needs. Yorke (2006:13) substantiates this by the statement “...employability goes well beyond the simplistic notion of key skills, and is evident in the application of a mix of personal qualities and beliefs, understandings, skilful practices and the ability to reflect productively on experience…in situations of complexity and ambiguity.”

## 3.7 CONCLUSION

Chapter 3 covered an in-depth literature development of industrial engineering, addressing several aspects related to the study. To summarise:

- **Quality in industrial engineering:** A description of what quality is, was discussed in Chapter 3, giving the reader a general perspective of quality as viewed by two stake holders in the study environment i.e. the institutions of higher learning and the industry. The researcher discussed the measure of quality based on a mathematical formulary and a model which will be useful in measuring the effectiveness and efficiency of the samples under study.
- **Skills level and its impact on productivity:** The researcher discussed the principles and the nature of productivity and its relationship to a system which is synonymous with industrial engineering. Allowing the reader an insight into the value if the industrial engineering skill.
- **Value of industrial engineering:** At this stage the reader is provided with a an overview of the limited nature of the industrial engineering skill and the much needed increase in the number of qualified and skilled engineers leaving the institutions of higher learning.
- **Expectations placed on graduate industrial engineers and the responsible governing bodies:** The researcher culminates with an overview of the roles played by an industrial engineer in industry and the academic requirements needed to perform within this field, including the academic limitations in producing the needed number of graduates. The reader is further informed on methodologies adopted in sourcing and recruiting engineers and the quality assurance requirements placed on both academia and industry in measuring and ensuring a sound credible and reliable profession.

Chapter 4 elucidates further on the research process undertaken to study the various sections discussed in Chapter 3. The chapter will describe the data mining methodologies used in the investigation process and the survey design adopted, among other pertinent facets of the research design and methodology.

# CHAPTER 4: RESEARCH DESIGN AND METHODOLOGY

## 4.1 INTRODUCTION

This chapter focuses on the geographical area where the study is to take place. The study design employed and the population parameters including the research boundaries and the target population will be elucidated. The research will encompass the institutions of higher learning, the specific industrial engineering business, and the student communities within respective institutions around the South African region. Focus will be on several key groups within the environments mentioned above, these are:

- Two academic universities ;
- Two universities of technology; and
- Industry representatives

## 4.2 PURPOSE OF THIS CHAPTER

The research survey and questions posed will focus on attempting to answer the following; whether a gap exists between industry expectations of students graduating within the industrial engineering field and the ability of these students to meet these needs and if so briefly highlight what areas of needs are to be met to minimize the gap. The objective is aimed at solving the research problem as defined in the problem statement of this research, which reads as follows: There is a lack of adequate communication between industry and institutions, the result of which, the skills level and academic qualification attained by graduating industrial engineers do not meet industry expectations.

## 4.3 SAMPLING METHOD

There are two main types of samples generally considered acceptable in statistics probability or representative sampling and non-probability or non-representative sampling (Watkins, 2008:54-57):

**Probability sampling / representative sampling:** considered most reliable and come in two forms random and stratified.

- **Random sampling:** assumes that any variations in the sample are due to chance i.e. equal chance of selection as shown in figure 4.1 below:

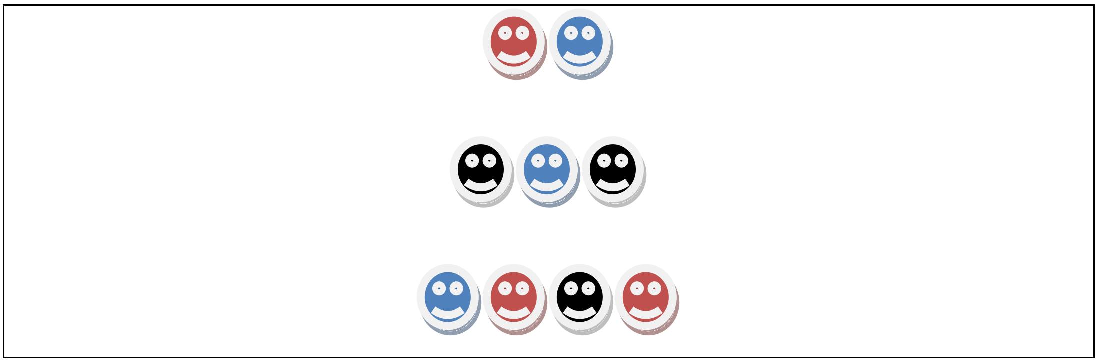

**Figure 4.1**: Random sampling (Source: *Anonymous, 2012*: **O**nline)

- **Stratified sampling:** on the other hand, is more defined in its representation as it looks at specific subgroups within subgroups according to the nature of the target sample. For example, in the case of this research, to obtain a stratified sample of university students, the researcher organised the population by institution, followed by department and then selects required numbers of exit level students in industrial engineering as shown in figure 4.2 below.

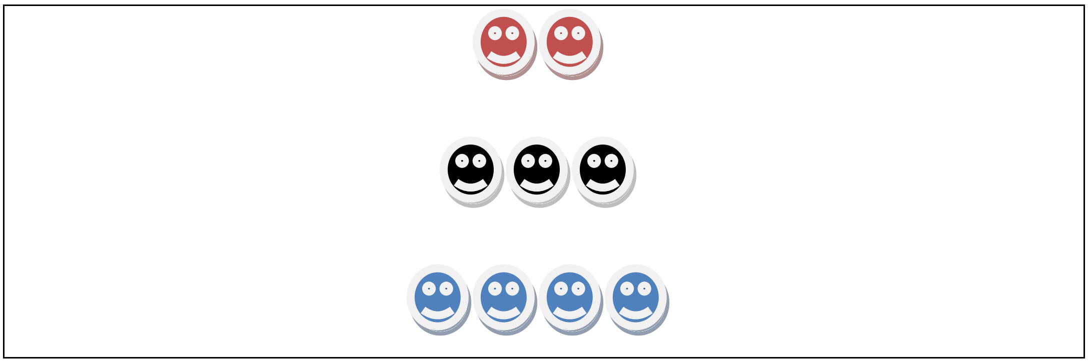

**Figure 4.2:** Random sampling (Source: Source: *Anonymous, 2012*: **O**nline)

**Non-probability sampling / non-representative sampling:** considered less reliable and expansive in its representation thus may tend to be inaccurate in its inferential ability, however useful in sampling a poor or inconsistent sample group. They come in several forms: quota sampling, convenience sampling, and purposive sampling (Watkins, 2008:54-57).

- **Quota sampling:** setting deliberate strata proportions without a factual basis on samples; allows the researcher to represent the population in cases where availability of a sizeable population.
- **Convenience sampling:** sampling randomly without a specific sample size in place; focuses on specific sub-groups within the population that remains difficult to isolate.
- **Purposive sampling:** is specific to a particular subgroup due to the nature of research the subgroup has on the study question. The subgroup may exhibit characteristics like being too small in sizes, changing / dynamic form.

The sampling method adopted took the form of stratified random sampling where specific sets of samples were identified; their relationships described and assumptions on their influence on the outcomes noted. The sample frame was made up of three frames of four subgroups as described in section 4.1 of Chapter 4, each focusing on a particular perspective of the of the research problem. The survey frame list follows a prescribed set of characteristics as iterated by Sapsford and Jupp (2006:29).

An ideal sampling frame will have the following qualities:

- The sample variables have a logical numeric identifier i.e. the representative samples are identifiable through available contact information, map and location.
- The groups are logically aligned as follows in figure 4.3.
- The frame has additional information about the units' structure such as job descriptions, curriculum components, and students' subject profile for further research.
- Every aspect of the population of interest is present as shown in the model above.

- The representative population subgroups are only surveyed once in the research.
- No foreign elements are introduced into the present survey frame.

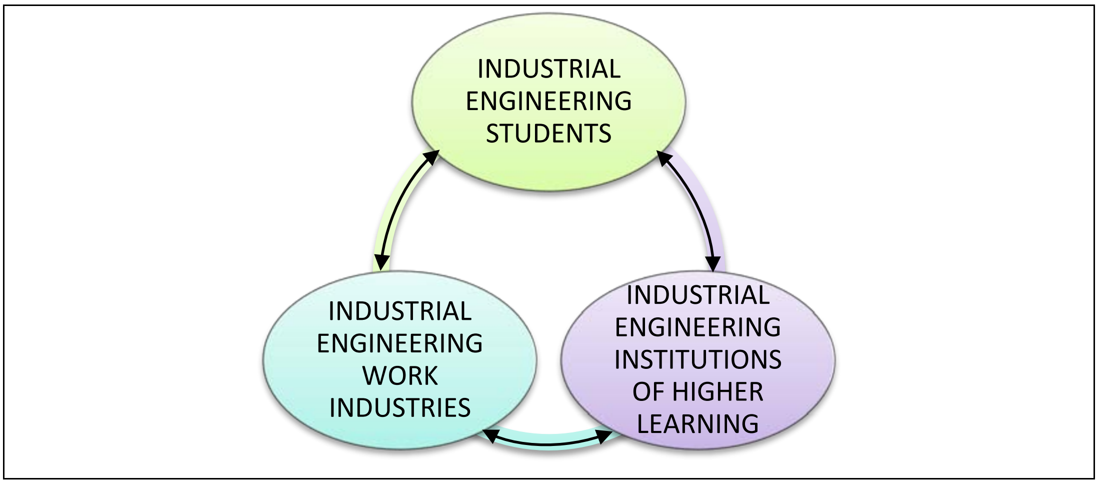


**Figure 4.3:** Relationship model (Source: Stevenson, 2008:20)

The interrelationship between the three quadrants highlight the institutions influence on the student's level of skills knowledge acquisition in industrial engineering and further demonstrates the interdependence between the students and industry in relations to the ability of the student in meeting the expectations industry places on their work ability. Lastly, a two-way relationship is described between the institution and the industry in building and developing materials relevant for teaching skills needed by industry to students (Stevenson, 2008:20). The question is; does academia meet the students need for the skills expected to effectively and efficiently provide for industry in their work performance?

## 4.4 THE TARGET POPULATION

*"By a small sample we may judge the whole piece."* - translated from Don Quixote by Miguel de Cervantes (1547-1616).

According to Collis and Hussey (2009:77), a target population is any specifically defined body of people or objects under consideration with the intent of drawing inferences. Collis and Hussey (2009) and Babbie (2009:199), further describe a random sample vis-à-vis a sample, as a subset of a population, one chosen by a method involving an unpredictable element, which in this study will be defined by randomly sampling within the three-major groups as identified in the model in figure 4.3. These sub-groups are:

- **The University of Stellenbosch (academic university):** Sample includes mid to exit level students and lectures
- **The University of Pretoria (academic university):** Sample includes mid to exit level students and lectures
- **University of Johannesburg (university of technology):** Sample includes mid to exit level students and lectures
- **Cape Peninsula University of Technology (university of technology):** Sample includes mid to exit level students and lectures
- **Industry representatives:** Sample includes the South African Institute of Industrial Engineers (SAIIE) and the Engineering Council of South Africa (ECSA)

The sample size does not generally prescribe to a set requirement or instructions as far as size is concerned, however a recommendation according to Brink (2006: 135), the larger samples the better the outcome of the study are often used in quantitative studies (Brink, 2006:135). Watkins (2008:57) provides some general guidelines in table 4.1 for the sample size of a study:

**Table 4.1:** Sample size decision table (Source: Watkins, 2008:57)

| **Population size (n)** | **Percentage recommended** | **Number of participants (n)** |
|---|---|---|
| N < 50 | 100% | n < 50 |
| 51 < N < 100 | 75% | 38 < n < 75 |
| 101 < N < 500 | 50% | 51 < n < 250 |
| 501 < N < 1000 | 35% | 175 < n < 350 |
| N > 1001 | N/A | N = 400 |

The random sample in the study consists of students, staff and management of higher learning institution of the University of Stellenbosch, University of

Pretoria, University of Johannesburg, and Cape Peninsula University of Technology. Twenty heads of department, two hundred students, and five industry representatives were selected for the study, as depicted in table 4.2.

**Table 4.2:** Proposed sample summary table (Source: Own source**)**

| **Organisation** | **Sub-group** | **Sample size (n)** |
|---|---|---|
| University of Stellenbosch (academic university) | Lectures | 3 |
| | Middle to exit level students | 25 |
| University of Pretoria (academic university) | Lectures | 3 |
| | Middle to exit level students | 25 |
| University of Johannesburg (university of technology) | Lectures | 3 |
| | Middle to exit level students | 25 |
| Cape Peninsula University of Technology (university of technology) | Lectures | 3 |
| | Middle to exit level students | 25 |
| Industry representatives | South African Institute of Industrial Engineers (SAIIE) | 30 |
| | Engineering Council of South Africa (ECSA) | 30 |

From the target population of one hundred and seventy two randomly selected participants within the sample frame, only one hundred and fifty four participated / returned the survey. Of the one hundred and fifty four positive participants, twelve staff and management members of institutions of higher learning, sixty seven industry representatives (more than the expected) and seventy five students (less than expected) returned their completed Questionnaires. From this data, descriptive and inferential statistics were compiled and inferences discussed in Chapter 5.

## 4.5 SURVEY DATA COLLECTION AND DESIGN

The research as previously mentioned took the form of a quantitative approach. Burns and Grove (2009:22) define quantitative research as a formal, objective, systematic process to describe and test, relationships, and examine cause and effect interactions among variables. Babbie (2007:244) refers to a Survey, as a data collection method used to gather original data from a specified population using a standardized set of questionnaires given to a sample of participants / respondents to be used for descriptive, explanatory, or exploratory purposes, as this study will show. The descriptive survey design adopted collected original data used in describing the population under study and retrieved information from a sample of participants by means of a self-administered survey interviews and questionnaires.

### 4.5.1 The Likert-type scale Questionnaires

A set of fifty-one Likert-type close-ended questionnaires were administered during the survey by the researcher and distributed through various electronic and physical means. Burns and Grove (2009:374) iterates that a nominal scale measurement is useful in measurement of data that is not in any particular order but that can be classified into particular categories, for example information cited in the study survey regarding age, gender and level of qualification are asked. The Likert scale used in the study, allowed contextual information gathered from the questionnaire to measure by way of ranking, the opinions or attitudes of the respondents to questions related to the: study environment, subject parameters and the skills environment of industrial engineering (Burns and Grove, 2009:410). The ranking comprised of a five-point scale shown in table 4.3 shown below:

**Table 4.3**: Five-point scale table used in the questionnaire (Source: Own source)

| **Decision options** | **Strongly agree** | **Agree** | **Uncertain** | **Disagree** | **Strongly disagree** |
|---|---|---|---|---|---|
| Code | 1 | 2 | 3 | 4 | 5 |

### 4.5.2 The face-to-face interview sessions

The industrial engineering academic staff responded to a series of thirteen open-ended statements in the form of scheduled interviews to develop a richer database Babbie (2007:246). See annexure C for the interview output.

The interview sessions aimed at answering the following statements related to industrial engineering industry vs. academic effectiveness and efficiency. The statements asked were as follows:

- **"What is quality in industrial engineering?"** by aiming at understanding how effective is industrial engineering in offering a quality level of service in industry and academia.
- **"How do we achieving quality industrial engineering"** by aiming at answering  question one by looking at how efficient is industrial engineering in achieving quality in work as applied to real world environments like the workplace and in producing a workable, competitive workforce.

In understanding the opinions posed by the respondents, a deeper knowledge of factual understanding and perception of the research subject needs to achieved and inferences related to the problem objectives answered. To summarize, the three frequently used types of surveys are face-to-face interview, written questionnaire, and telephone interview. They all vary in terms of cost incurred for every respondent and the types of questions you can ask. A comparison table 4.4 shows the pros and cons of the three types of surveys (Leedy and Ormrod, 2005:185)

**Table 4.4:** Survey type comparison table (Source: Leedy and Ormrod, 2005:185)

| Type of survey | Pros | Cons |
|---|---|---|
| Face-to-face Interview | Explain questions, explore issues, make observations, and use visual aids. | Expensive, need interviewer training |
| At home or work | Accuracy, better sampling | Expensive |
| In public places | Cheaper, more people in less time | Less representative sample |
| Written questionnaire | Cheapest per respondent | Bias from low response rate |
| By mail | Allows anonymity | Slow |
| By e-mail | Cheaper, quicker results | Less representative sample |
| Web survey | Quicker data processing | Need computing expertise |
| Telephone survey | Accurate, cheap | No personal observations |

In retrospect to interview and questionnaire forms of surveys, Leedy and Ormrod (2005:185) highlight that participants will be more candid in responding to questions posed in a questionnaire since it allows the participants to remain anonymous as opposed to personal interviews. On the other hand, having varying forms of surveys in one study adds immense value and insight on the perspective of the study, as one can have a wider expansive viewpoint of the study.

## 4.6 SURVEY DESIGN

A descriptive survey was selected because it provides an accurate portrayal and account of the characteristics, for example behaviour, opinions, abilities, beliefs, and knowledge of a particular individual, situation, or group (Babbie, 2007:244). This design was chosen to meet the objectives of the study, namely to determine the knowledge and views of:

- Students' knowledge and understanding of industrial engineering vis-a-viz its impact in industry and level of employability.
- The institutions' management i.e. academic staff in as far as their knowledge, understanding, and level of service they are offering this skill.
- The industry representatives' expectation of students entering the job market with regard to level of skills students are expected to attain and the ability of these students to perform according to industry standards set upon them within their respective industrial engineering working positions.

The survey statements covered a wide scope in order to meet the expanse of the sample frame while capturing a respectable sample stratum. The statements were posed to willing participants; whose responses were gathered and ultimately summarized into numeric percentages, frequency counts, and / or into more advanced statistical indexes; which would conclude with a series of inferences surrounding the particular population under question. Watkins (2008:140) cites Leedy and Ormrod (2001) by highlighting the following nine steps shown in table 4.5 below, necessary in developing a questionnaire-based survey:

**Table 4.5:** Survey questionnaire development table (Source: Watkins, 2008:140)

| **Steps** | **Procedure** |
|---|---|
| **1** | Determine the research question or hypothesis statement and key research objectives. |
| **2** | Develop a questionnaire based on relevance of the proposed research to be conducted. |
| **3** | Identify the sample frame from the target population and select a sample. |
| **4** | Choose as interviewing method. |
| **5** | Pilot the survey. |
| **6** | Conduct the survey. |
| **7** | Data processing. |
| **8** | Data analysis follows which includes descriptive analysis and statistical inferences. |
| **9** | Formulation of the report in order to draw conclusions and interpret findings. |

According to Watkins (2008:141-143), questions designed for the purposes of a survey should be to the point and concise enough to answer the primary objective of the research adding that a quality question allows for the mitigation of the research problem thereby development of the solution to the problem. Watkins further highlights; a researcher should avoid double-barrelled questions, are biased, leading and assumes prior cognition as this may taint the outcome by inadvertently steering the participant towards a preconceived answer.

## 4.7 RELIABILITY AND VALIDATION OF SURVEY AND INTERVIEW QUESTIONS

Girden and Kabacoff, (2010:3) refers to empirical research as having two of three concepts associated to it one being reliability and the other validation. Girden and Kabacoff (2010) further stress that research should be consistent and repeatable while maintaining a sense of meaningfulness in serving the intended purpose.

### 4.7.1 Reliability

According to Girden and Kabacoff (2010:3), reliability means consistency and repeatability. In addition, they refer reliability to precision of measuring instruments used. When replicating the experiment under similar environmental conditions, the results should be similar. This means that the results mined from a survey study should have on average the same 'score' when repeatedly conducted, on the same relative subgroups / participants.

The three questionnaires, answered by all sub groups, showed consistency in responses while maintaining similar standings on the level of participants from one institution to the other. Furthermore, in order to ensure that reliability variations were minimised, data collection bias was narrowed to one administrator conducting the survey both electronically and in person and ensuring, that the administrator exhibited similar personal attributes to all respondents, i.e. hospitality and support. The data collection environment, maintained a sense of privacy and confidentiality and general physical comfort by providing several avenues of data capture specifically through two mediums; electronic and manual survey questionnaires. The participants were given ample instructions on how to fill the questionnaire including requests not to write their personal particulars i.e. names on the questionnaires to ensure confidentiality. The participants were given time to familiarise themselves with the questionnaire and allowed to respond to queries before administering the survey.

### 4.7.2 Validity

Girden and Kabacoff (2010:3-4) refer to validity of an instrument, as the ability to provide appropriate, useful and meaningful feedback. They further stress that validity should express valid and conclusive responses. Content validity signifies the extent to which an instrument represents the key factors under study. Three forms of validity paramount to research according to Girden and Kabacoff (2010:3-4) are;

- **Internal validity:** refers to the degree of relationship between variables; a positive relationship may be termed causal and a negative relationship a lack of cause.
- **Statistical conclusion validity:** refers to the appropriateness of the statistical method employed in order to determine variations between data.
- **External validity:** refers to the degree to which research findings can be indiscriminate beyond the sample used.

To achieve content validity, questionnaires included a variety of statements on knowledge and views of the following:

- **Students'** knowledge and understanding of industrial engineering vis-a-viz its impact in industry and level of employability.
- **The institutions'** management i.e. academic staff in as far as their knowledge, understanding and level of service they are offering this skill.
- **The industry representatives'** expectation of students entering the job market with regard to level of skills students are expected to attain and the ability of these students to perform according to industry standards set upon them within their respective industrial engineering working positions.

Internal validity was ascertained by basing statements on information gathered during the literature review to ensure that they were representative of what students, institution of higher learning lecturers and industry representatives need to know about industrial engineering in all aspects of the three environments. The statements were formulated in simple language for clarity and ease of understanding. The interview session of the survey was conducted first in order to validate and clarify the close ended questionnaire, which was handed out last to all participants. As a result, more statements were added and others redefined on the closed-ended questionnaire to ensure a richer representation of the population. External validity was maintained by ensuring all the persons approached to participate in the study completed the questionnaires. No single person who was approached refused to participate. See annexure C for the interview output.

### 4.7.3 Survey statements

The survey statements administered focused on the following participants:

- Two academic universities
- Two universities of technology
- Two Industry representatives, including various other industrial engineering professionals

The questionnaire was administered in two parts:

**Part One:** required the participant to answer closed ended statements entailing their demographics and professional background.

**Part Two:** required the participant to answer closed ended statements covering the position held in the organisation, qualification being studied, years of educational and / or industry experience / level of studies / years of association / membership and gender

Three separate questionnaires similar in design and nature were developed for each subgroup. A distinction per questionnaire was intentionally built in through re-structuring each survey according to the environment suitable to the sub-group in question. The reason behind the distinction allowed the researcher to determine whether students, management and industry perceived similar or dissimilar views regarding the quality of industrial engineering both in academia and industry thereby establish a whether a gap exists.

Each questionnaire was broken into three distinct sections covering three prescribed environments of industrial engineering. Firstly the Academic environment seeking the perception of industrial engineering in as far as knowledge understanding and creation, secondly industrial / work environment, seeking the perception of industrial engineering's' impact in the business organisation and lastly quality environment of industrial engineering, seeking the perceived level of 'value' understood in this engineering skill. It is worth noting that, Babbie (2005:285), states that surveys in research are usually feeble on validity, and strong on reliability.

The statements stated in part two of the surveys were categorized as follows:

- **Industrial engineering in industry**

Aim: This area of questioning attempts to comprehend and clarify the perspective the stakeholders i.e. student, employer, and the institution have on the role industrial engineering in industry vis-a-viz 'value added' and the impact it has on the quality of life within the three environments. The statements were as follows:

**1.** I have a clear understanding of industrial engineering as a branch of engineering.
**2.** I am curious about industrial engineering.
**3.** I know clearly, where industrial engineering originated from in the South African Industry.
**4.** Industrial engineering plays a key role in the manufacturing and service industry in South Africa.
**5.** The South African economy is influenced by the role played by industrial engineers in Industry.

**6.** There is an adequate awareness of industrial engineering by the Industry regionally and nationally.

**7.** I have a student to mentor / role model relationship with an industrial engineer in Industry.

**8.** My institution is capable of skilling me to becoming a productive industrial engineer.

**9.** I need a Bachelors degree and above in industrial engineering to become adequately skilled to perform well in Industry.

**10.** I plan to pursue industrial engineering related projects and activities in Industry.

- **Industrial engineering in academia**

Aim: This area of questioning attempts to comprehend and clarify the perspective the stakeholders i.e. student, employer, and the institution have on the role industrial engineering in academia vis-a-viz ‘value added’ and the impact it has on the level of performance expected from graduating industrial engineering graduates on completion of their respective programme tenure. The statements were as follows:

**11.** I understood what I wanted to do before completing my final high school qualification.

**12.** I chose industrial engineering as my first choice of study.

**13.** I am passionate about learning industrial engineering.

**14.** Industrial engineering is a branch of engineering that I have come to or coming to have a clear understanding of.

**15.** My institution has the practical capacity to teach me industrial engineering using labs, workshops and industry visits among others.

**16.** I decided on my current institution of learning as my first choice to pursue my desired qualification.

**17.** Industrial engineering qualification comes in various NQF levels that I fully understand e.g. National diploma, B.Tech, and B degree among others.

**18.** I fully understand what my curriculum expects of me.

**19.** My institution is offering me qualified teachers and teaching aids to allow me to fully understand the theory and practice of industrial engineering.

**20.** My institution makes me believe that my career choice can make a difference in my life and the economy.

**21.** I have the full support I need from my teaching instructors.

**22.** I feel personally encouraged to learn industrial engineering.

**23.** I am currently on a bursary or financial aid and not supported by my guardian or myself.

**24.** My finances are adequate to cover my full academic tuition and living standards.

**25.** I am fully supporting myself through my industrial engineering studies.

**26.** I know and understand the South African Qualifications Framework.

**27.** I understand the various industrial engineering NQF level descriptors.

**28.** My course structure was fully explained to me through the subject Study Guide.

- **Quality in industrial engineering**

Aim: This area of questioning attempts to comprehend and clarify the perspective the stakeholders i.e. student, employer, and the institution have on the quality of industrial engineering vis-a-viz ‘value added’ and the impact it has on the level of performance in developing graduates and employees who are adequately skilled, employable and competitive in industry. The statements were as follows:

**29.** The definition of industrial engineering is quality in itself.

**30.** Industrial engineering is an innovative, knowledge based and enterprise based thinking process.

**31.** The current teaching material in South Africa is relevant to the industrial engineering qualification in South Africa.

**32.** The South African Industry objectives e.g. improving productivity and among others, is in line with what is taught at my institution.

**33.** We have regular input (e.g. forums) from Industry regarding the impact industrial engineering has on Industry performance.

**34.** The level of teaching is adequate to skill the current industrial engineer.

**35.** The material taught to me in class is well understood and adequately links with the skills necessary to work in Industry.

**36.** When applying to study industrial engineering at my institution, the process was clear and easy.

**37.** The registration procedure and requirements was run smoothly and not stressful.

**38.** I have a healthy and conducive study environment.

**39.** Information on industrial engineering at the institutions' classes, teachers and the library is readily available.

**40.** The evaluation process conducted for industrial engineering at the institution is fair and unbiased.

**41.** I have adequate access to my teaching instructors.

**42.** The institution offers other means of developing my studies through e.g. tutor, tutorials, projects and among others.

**43.** I am able to interact with institutions and groups internally and externally to develop my knowledge of industrial engineering e.g. discussion groups.

**44.** My institution interacts with industry stakeholders to develop industrial engineering to meet current industry standards.

**45.** My institution organises research, student projects, competitions and among others funded by Industry to bring awareness to industrial engineering and the students studying the course.

**46.** My family is intimately involved with my performance and studies at the institution.

**47.** My department interacts and supports students through healthy interventions with evaluation performance.

**48.** There is a positive attitude within the industrial engineering teaching environment.

**49.** My industrial engineering Department supports its instructors with the resources necessary to perform their duties.

**50.** I am aware of the quality assurance bodies that monitor my industrial engineering programme at my institution.

**51.** My institution interacts with the Engineering Council of South Africa together with students to develop industrial engineering.

### 4.7.4 Survey interview

The survey interviews administered focused on the following participants; two academic universities and two universities of technology Four similar interview surveys were designed with the intention of understand and clarify the direction industrial engineering is facing with respect to:

- Current level of industrial need, skill and application;
- Knowledge base surrounding industrial engineering; and
- Innovation of the skill and competitive edge.

Four leading industrial engineering teaching staff from four institutions of higher learning were sampled, by formulating two main questions; part one asking ‘what is quality in industrial engineering and is industrial engineering offering a quality level of service in industry and academia?’ This addressed the application of industrial engineering in industry and how relevant is it in the current economic arena of South Africa. The question statement went as far as enquiring as to the relevant principles and knowledge base that industrial engineering subscribes to in industry as well as in academia i.e. subject requirements innovation, enterprise management among others. The question statement sought to investigate and clarify the level of effectiveness of the study sample group

Part two of the question stated ‘how do we achieving quality in industrial engineering and is industrial engineering achieving this level of quality in the work environment as applied to real world workplaces and in effecting the academic production of an employable graduate who is competitive enough to achieve gainful employment? This question statement dwelt a myriad of areas namely; on understanding the academic process i.e. teaching principles, curriculum approach, and requirements, the teaching and learning process including the continuous evaluation, and exclusion policy among others. Other areas addressed here included the knowledge management of industrial engineering i.e. research, publications, and postgraduate studies, among others and the quality management process that assesses and controls the learning programme in academia i.e. methods of teaching / delivery, quality control and assurance measures and the industrial engineering skill as it is in industry. The intent focused on educating and enriching the researcher as to the level of efficiency of the sample group.

The following is the sample script of the interview questionnaire as discussed above. See annexure C for the interview output.

**PART 1:**

**What is quality in industrial engineering?**

1. “What is the innovative management theory as far as industrial engineering is concerned and how is this relevant in the South African context?”
2. “What is the ‘applicable relevant content?”
3. “Is the ‘applicable relevant content’ aligned with the current industry stakeholder objectives?”
4. “What are the resources and skills necessary to understand this theory?”
5. “What are the qualities applicable to an industrial engineer?”

**PART 2:**

**Achieving quality in industrial engineering**

1. “How is this knowledge created?”
2. “How is this knowledge developed or mined?”
3. “How is this knowledge compiled for relevance within the teaching curriculum for students to understand?”
4. “What is the integrity of the academic process and how is it managed?”
5. “How is the student application registration process managed?”
6. “What approach is used in the delivery of this skill?”
7. “What evaluation criteria is followed, and why?”
8. “Graduation process and passing criteria?”

### 4.7.5 The measurement model

The previous models mentioned in Chapters 3 and 4 need to be given a fair amount of discussion at this juncture to better understand their role in the study. The two models considered; one being the relationship model in figure 4.4 below showing the three players or sample groups and the second model in Chapter 3, figure 3.1, showing the effectiveness and efficiency value model. The relationship model as mentioned describes the interrelationships between the three sample groups. It highlighting the institutions influence on the student's level of skills knowledge acquired in studying industrial engineering and further relates the interdependence between the students and industry in relations to the ability of the student in meeting the expectations industry places on their work ability. Lastly, a two-way relationship exists between the institution and the industry in building and developing materials relevant for teaching skills needed for industry to academia for students. The question is; does academia in communication with industry meet the students need for the skills expected of them to effectively and efficiently work for industry?

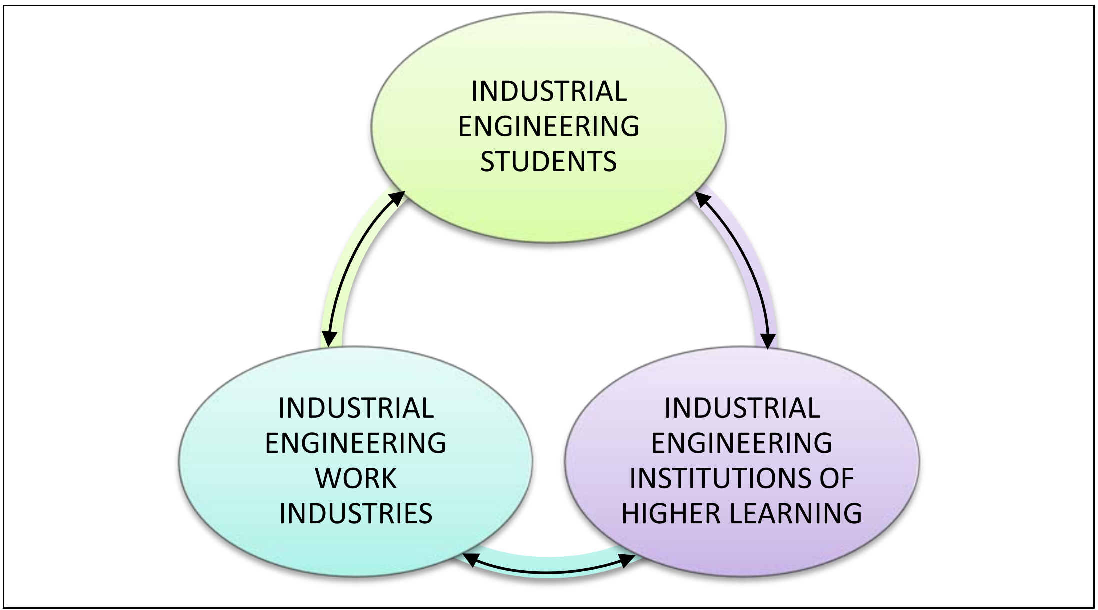


**Figure 4.4:** Relationship model (Stevenson, 2008:20)

The relationship in figure 4.4, describes effectiveness and efficiency of doing 'things', as described earlier in Chapter three. The model describes the four quadrants (A, B, C, D) shown in the model as the ‘value’ environments that the three sample groups may behave under. In order to derive value from the stated statements in Chapter 1; Business / industry needs to provide for academia in as far as effectively describing the skills needed by industrial engineering and efficiently making provisions for this skill to be achievable in academia. This is important since industry dictates and sets the tempo of academic development. Institutions on the other hand are tasked with ensuring that the right curriculum for the right skills development is laid down and taught in the right way for achieving skills growth.

Lastly, the group that both environments are dependent on; the students; are tasked with being able to effectively derive knowledge and utilize this knowledge to achieve value in their work. How effective are students at acquiring knowledge and how efficient are they at utilizing this knowledge? Is there a fair amount of understanding in order to achieve efficiency of working? Is there a fair amount of passion required to succeed and derive motivation from? These environments are depicted as behaving within the various quadrants, allowing the reader to better understand the circumstances surrounding the argument of the gap between industry expectations of students and the ability of students to meet this expectation. Using this model to measure the effectiveness of the three environments in doing the right ‘thing’, at bridging the gap stated in the problem statement and the efficiency of the three environments at ensuring quality of value in industrial engineering to ensures sustainability e.g. gainful employment, in industry, academia and students.

## 4.8 CONCLUSION

Chapter 4 discussed the research design and methodology, generalising on the subject and narrowing down on the approach applicable to this study. The chapter expounded on several aspects, firstly the population represented within the ambits of Chapter 3, and secondly the purpose and logic behind the choice of sampling techniques, data collection and design approaches suitable for the study. Lastly the reader was proffered on the applicable measurement scales and rational of the process, in order to prepare the reader for the analysis procedure examined in Chapter 5, from which the results were measured and inferences drawn.

# CHAPTER 5: RESEARCH RESULTS

## 5.1 INTRODUCTION

The purpose of this study was to explore the correlation between industry skills expectations placed on industrial engineering graduating students and the academic ability to meet this need. The study needs to satisfy the researchers' enquiry in as far as the level of quality of graduating South African industrial engineers who are actually employed within the relevant job market and the expected growth. In addition, the needs of the job industry are ideally expected to be met by the various learning institutions i.e. universities as is the case, placing responsibility on both industry and universities to ensure that students learn what is relevant and useful for job performance and development. The researcher sampled one hundred and fifty four individuals in table 5.1 as follows:

**Table 5.1:** Actual sample summary table (Source: Own source)

| Organisation | Sub-group | Sample size (n) |
|---|---|---|
| University of Stellenbosch (academic university) | Lectures | 3 |
| | Middle to exit level students | 20 |
| University of Pretoria (academic university) | Lectures | 3 |
| | Middle to exit level students | 20 |
| University of Johannesburg (university of technology) | Lectures | 3 |
| | Middle to exit level students | 15 |
| Cape Peninsula University of Technology (university of technology) | Lectures | 3 |
| | Middle to exit level students | 20 |
| Industry representatives | South African Institute of Industrial Engineers (SAIIE) | 65 |
| | Engineering Council of South Africa (ECSA) | 2 |

The researcher used a self-administered five-point Likert scale questionnaire designed around a nominal and ordinal scale, to represent observations assigned according to categories based on equivalence as described within the scope of Chapter 4. A descriptive and inferential statistical analysis was executed using Microsoft's excel application programme designed and created by Del Siegle (Siegle, 2012: **O**nline), to calculate Cronbach's alpha coefficient. The open-ended statements in the form of interviews assisted the researcher in drawing a deeper understanding of the subject and were analysed using a quantitative and qualitative approach in order to draw on and quantify new and developing characteristics, qualities and concepts of the environment under study (Williams, 2011). A frequency table displayed in annexure A shows the distribution of statements and responses.

## 5.2 ANALYSIS METHOD

### 5.2.1 Data format and preliminary analysis

The study employed the use of a web based electronic data collection format called Inqwise, designed and developed by Basil Goldman (Goldman, 2012: **O**nline). The website hosted and facilitated the communication of the questionnaires administered to the participants. A letter of invitation was sent to participants, see annexure D, which preceded the administration of the electronic survey. Prior to analysis, the data mined from Inqwise, was stored in Microsoft excel. Attached at the back of this study under Annexure B is the raw data resulting from the analysis. The following was adhered to while preparing to analyze the data:

- Values were rounded off to whole values.
- Descriptive statistics was used to ascertain the frequency, range, mean and standard deviation of the statements.
- Exemplars in the form of frequency tables or histograms were used to describe the variables and the distribution of data.

### 5.2.2 Inferential statistics

Inferential statistical data testing and analysis discussed by Healey (2011:8-15) and Watkins (2008:164) suggest that captured research data may be investigated in various forms, three of which were adopted in this research:

- **Reliability analysis test employing Cronbach's alpha coefficient:** The tools' application in this study allows for the validation of consistency in data. When using the Likert-type scales, it is imperative to calculate and report Cronbach's alpha coefficient for internal consistency for any scales or subscales one may be using (Gliem and Gliem, 2003). The Alpha coefficient ranges between zero and one. Zero being less reliable and a higher value referring to a better reliability. The coefficient is used to describe the reliability of aspects derived from statements with two possible answers and / or multi-point formatted questionnaires or scales, as is the case with the data presented in this study.
- **The Spearman's rank:** was applied to determine the extent or the degree of correlation between industry skills expected of graduate industrial engineers and the academic ability of students, vis-a-vie higher learning institutions, to meet this need.

## 5.3 ANALYSIS

### 5.3.1 Descriptive statistics

The following section illustrates the distributions of statements and responses of the descriptive data compiled for the survey. The tables shown highlight the structure and findings per category tallied according to frequency and percentages out of the total samples from each individual group survey.

The sub groups are:

- Student survey sampling four industrial engineering universities from various regions in South Africa (two academic universities and two universities of technology).

- Institution (Lecture) survey sampling four industrial engineering universities from various regions in South Africa (two academic universities and two universities of technology).
- Industry representatives survey sampling two professional bodies responsible for monitoring and standardizing the engineering skills both at academic level and industry level. (SAIIE, Southern African Institute of Industrial Engineering and ECSA, Engineering Council of South Africa). As mentioned earlier, these bodies were considered a representative of the industry due to the role members play as professionals working within various disciplines as industrial engineers in the industry.

**Special case statement variables:** Statement *29 in the survey under the institution and the lecturers' survey, asked if there was support for individual self-development both in the academic arena and in the industry environment. This statement was not included in the students' survey since it was not relevant to the sample group. However, in the analysis stage it was interpreted separately to determine if the quality of industrial engineering vis-a-viz skills growth and knowledge development has an impact academically and in industry and as such conclude as to its influence in effectiveness and efficiency of the variables under study.

The overall response rate for this survey was ninety percent, which was considered favourable. The data is represented in annexure A.

### 5.3.2 Univariate graph analysis: A summary of the three environments

#### 5.3.2.1 Overall analysis of student responses

There was a significant positive response from the students on the impact industry and academia has on industrial engineering. It is however worth noting that quality in industrial engineering was not very confidently answered compared to the other subgroup statements of the survey. A number of students were undecided about most statements, possibly due to lack of awareness or exposure to the field of industrial engineering. It is worth noting however that a fair number of students in statement 11 showed they were unsure of what they wanted to study on completion of their matriculation studies. Although this is common among most students in general, it may have a bearing as to the quality of students received at higher learning institutions prior to admission to universities impacting on the growth curve of their post academic development. Statement 33 although having a positive feedback, it also received a fair amount of negative feedback making it difficult to judge whether the financial support or lack thereof impacts negatively or positively in their pursuit of industrial engineering education. It is worth noting that in Statement 9 eighty eight percent of students agree that a minimum requirement for industrial engineering in industry is a bachelor's degree, additionally, in statement 30, eighty one percent agree that industrial engineering is an innovative, knowledge and enterprise based thinking process.

The following is a summary of the overall analysis of student responses based on a significant percentage response related to discussions made in Chapter 3 of the literature review and the investigative sub-questions highlighted in Chapter 1 of the research:

- **Role of industrial engineering in industry:** Ninety percent of students understand and are passionate of industrial engineering and its role in industry as asked in statement 1 of the study. However there is a significant seventy seven percent and above uncertainty as to its origin, awareness and future role in industry as asked in statement 1 and 6 respectively.
- **Significance of industrial engineering in industry:** Eighty eight percent of students agree that industrial engineering plays a significant role in industry as answered in statement 4 of the study.
- **Minimum skills level of a qualified graduate industrial engineer:** Eighty eight percent of students agree that a minimum requirement for industrial engineering in industry is a bachelor's degree.
- **Knowledge of the existing SAQA qualification framework for industrial engineering:** Seventy six percent of students are aware, knowledgeable and understand the workings and interpretations of the national qualification framework.

- **Effective mechanism to enhance for high quality industrial engineers:** A significant percentage of students agreed that they receive adequate teaching material and effective teaching styles including support from tutors and industry interactions that enhance the quality of the skills being taught. Discussion groups, family and departmental interventions help enhance and counter challenges students may be facing in understanding the industrial engineering programme. Thirty three percent of students in Statement 51 agreed that interactions with the Engineering Council of South Africa (ECSA) in their institution help develop and keep industrial engineering current. In contrast however students answering Statement 50 stated that there is a lack of presence from within their institutions the quality assurance bodies such as the Engineering Council of South Africa (ECSA) and Southern African Institute of Industrial Engineers (SAIIE).

#### 5.3.2.2 Overall analysis of institution (lecturers) responses

Lecturers responded well to all the statements as seen in the institution (lecturer) questionnaire and by and large agreed as to the positive industry and academic impact of industrial engineering. It is evident that institutions of higher learning value industrial engineering in industry. It is however curious to note that statement 23 which looked at the remuneration compensated to lecturers received a negative feedback showing a need to investigate the lectures salary scales and its impact on academic development.

The following is a summary of the overall analysis of institution (lecturers) responses based on a significant percentage response related to discussions made in Chapter 3 of the literature review and the investigative sub-questions highlighted in Chapter 1 of the research:

- **Role of industrial engineering in industry:** Above seventy five percent of lecturers have a mastery understanding of industrial engineering and believe that it is a knowledge and information based skill, which industry can capitalise on.

- **Significance of industrial engineering in industry:** Ninety two percent of lecturers agree that industrial engineering plays a significant role in industry. Its responsibility in industry and history background is of great importance in influencing the South African economy. It's encouraging to note that a negligible number disagree with the above feedback depicting a strong sense of industrial engineering as a pertinent component in economic growth and sustainability.
- **Minimum skills level of a qualified graduate industrial engineer:** Eighty three percent of lecturers agree that a minimum requirement for industrial engineering in industry is a bachelor's degree and above.
- **Knowledge of the existing SAQA qualification framework for industrial engineering:** One hundred percent of lecturers are aware, knowledgeable and understand the workings and interpretations of the national qualification framework, and what is expected of industry. Very encouraging is the fact that eighty four percent of the lectures are in total agreement as to the nature of student and industry expectations and the importance to meet this need.
- **Effective mechanism to enhance for high quality industrial engineers:** A significant sixty seven percent of lecturers agreed that they receive adequate teaching material from their institutions and poses effective teaching styles including support from institution and industry interactions that enhance the quality of the skills being taught. It is important to take note that a thirty three percent of lectures feel that they are not adequately supported in their personal capacity to teach industrial engineering. Statement 21 highlights this personal inadequacy which begs for further investigation. This may possibly be due to the sixty six percent in disagreement as to the following Statement 22, which states; 'my current remuneration level is adequate given the work I do' i.e. for lecturing services rendered. Discussion groups, family and departmental interventions are significantly supported by lecturers. Thirty three percent and twenty five percent of lecturers in Statement 51 and 52 respectively, agree that interactions with the quality assurance bodies such as the Engineering Council of South Africa (ECSA) and Southern African Institute of Industrial Engineers (SAIIE) with their institutions help develop and keep industrial engineering

current. Statement 40 although positively answered, highlights an important fact that sixteen percent of lectures do not believe that students have adequate access to industrial engineering information within their institutions' libraries. This small percentage may be owing to the fact that there may be little South African industrial engineering literature students are able to take advantage of.

#### 5.3.2.3 Overall analysis of industry (SAIIE and ECSA) responses

Looking at the overall industry questionnaire, industry, generally agreed on industry and academic impact of industrial engineering. However, it is encouraging to note that industry regards the skill of industrial engineering as being in tune with quality. Worth mentioning is statement 6, the level of poor awareness industry believes industrial engineering has received, and statement 23 showing the poor financial support education and industry has received in research and development. This is an area worth exploring in further research since it rings true according to industry.

The following is a summary of the overall analysis of industry (SAIIE and ECSA) responses based on a significant percentage response related to discussions made in Chapter 3 of the literature review and the investigative sub-questions highlighted in Chapter 1 of the research:

- **Role of industrial engineering in industry:** Eighty eight percent of industry have a mastery understanding of industrial engineering and believe that it is a knowledge and information based skill, which industry can capitalise on.
- **Significance of industrial engineering in industry:** Ninety one percent of industry agrees that industrial engineering plays a significant role in industry and its responsibility in industry is of great importance in influencing the South African economy. Of significance, however, is the forty six percent of industry who are either uncertain or do not know the significant role the history industrial engineering has played in the South African economy while only fifty three percent of lecturers are in agreement as far as being knowledgeable of the fact. The actuality that seventy seven percent of industry disagrees as to the adequate awareness of industrial engineering in industry

regionally may attest to the lack of knowledge of the history of industrial engineering in industry. It’s encouraging to note that fifty five percent of industry believes that institutions are contributing to skilling productive industrial engineers, however thirty five percent are either uncertain or disagree with the fact.

- **Minimum skills level of a qualified graduate industrial engineer:** Eighty two percent of industry agree that a minimum requirement for industrial engineering in industry is a bachelor’s degree and above. Industry is encouraging further development and research as shown by the ninety four percent of individual industrial engineers either involved in or pursuing industrial engineering related projects and activities, showing a positive growth and advancement of industrial engineering knowledge and innovation in industry
- **Knowledge of the existing SAQA qualification framework for industrial engineering:** Above eighty percent of industry are aware, knowledgeable and understand the workings and interpretations of the national qualification framework, and what is expected of industry. Seventy eight percent of the industry is in agreement as to the nature of student and industry expectations and the importance to meet this need.
- **Effective mechanism to enhance for high quality industrial engineers:** Only forty nine percent of lecturers agreed that institutions of higher learning receive adequate teaching material and poses effective teaching styles including support from institution and industry interactions that enhance the quality of the industrial engineering skills being taught. It is important to take note that twenty nine percent of industry feels that they and institutions of higher learning are adequately supported in research and development of industrial engineering, the other seventy percent are in opposition and feel that more should be done to developed industrial engineering research and development within industry and institutions of higher learning. Statement 21 however, has an eighty nine percent agreement that industry is personally encouraged to develop industrial engineering as opposed to the lecturers’ views on this statement. Statement 24, shows eighty six percent agreement

that there is potential for further growth in studies on industrial engineering. Statement 48 shows that there is a seventy percent industry agreement that the teaching environment creates a positive attitude within industrial engineering. Under Statement 51, industry generally agree by forty three percent that institutions of higher learning actively and positively participate with quality assurance bodies such as ECSA and SAIIE in monitoring and controlling the quality of industrial engineering education. Fifty six percent of industry disagrees. In Statement 52, industry generally agrees that interactions with the quality assurance bodies such as the Engineering Council of South Africa (ECSA) and Southern African Institute of Industrial Engineers (SAIIE) and students of higher learning institutions is present so as to help develop and keep industrial engineering current. Forty seven percent of industry either disagrees or is uncertain. This may be due to Statement 50; Inadequate communication between industry and institutions of higher learning.

### 5.3.3 Univariate graph analysis: An in-depth analysis at the three environments

#### 5.3.3.1 Statements from the student environment

- **Students: Statement 1 to 10 on industrial engineering in industry:** This area of the statement focuses on comprehending and clarifying the perspective the students have on the role industrial engineering in industry, in adding value to the business and the impact it has on the quality of life through increasing productivity. The analysis is based on variables statement 1 to 10 of figure 5.1. From the graph in figure 5.1**Figure 5.1**, the students favoured statements 1, 2, 4, 8 and 9 demonstrating that there is a strong opinion on the level of passion and curiosity of industrial engineering in students. It is also evident that students are aware that industrial engineering plays a key role in the industry and that a minimum qualification of a degree is considered capable to allow one to earn a place in the industry. However, there still lies a level of uncertainty as to the direction and impact of industrial engineering in the economy evident from statement 3, 6 and 5. This possibly may be the reason as to why there exists an identity crisis on industrial engineering in industry. Discouraging is the fact statement 7 depicts a lack of student to mentor interaction from seasoned industrial engineers.

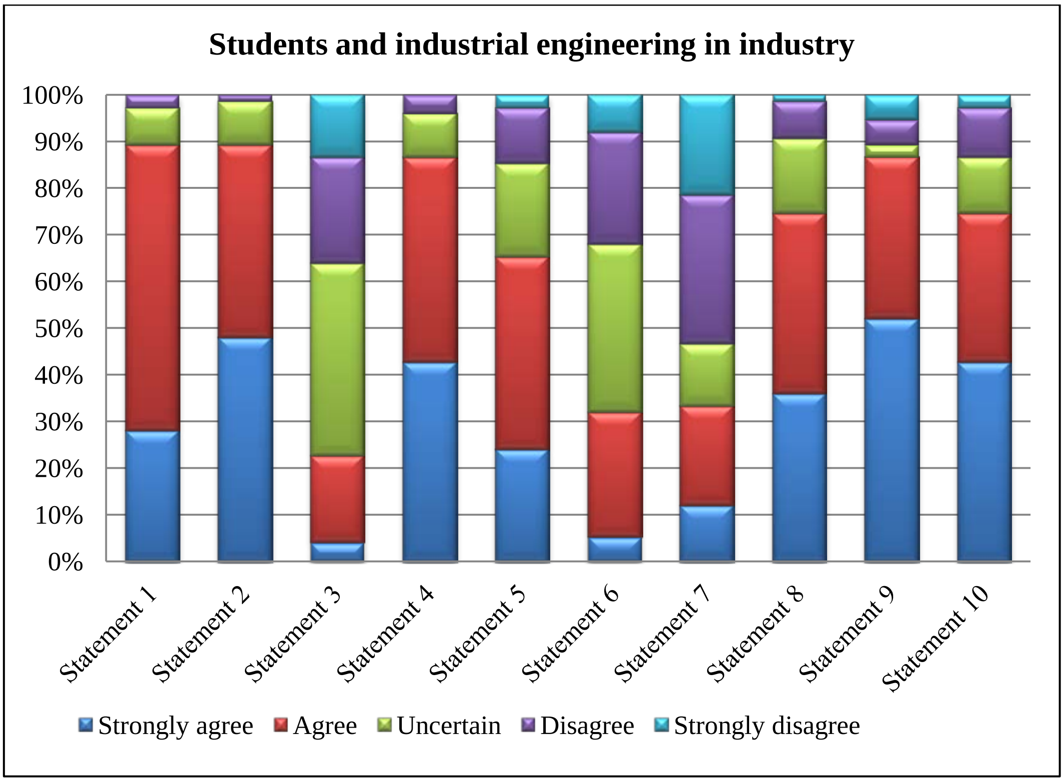


**Figure 5.1:** Stacked bar of students and industrial engineering in industry responses (Source: Own source)

- **Students: Statement 10 to 28 on industrial engineering in academia:** This area of the statement looks at the perspective the student has on the role industrial engineering plays in academia in adding value to the skill and the impact it has on the level of performance from graduating industrial engineering graduates on completion of their respective programmes. In asking these statements the researcher hoped to glean the students support structure, passion, understanding and knowledge of the academic curriculum and environment that is industrial engineering. The analysis is based on variables statement 11 to 28 of figure 5.2. Students responded to statements 13, 14, 16 to 22, 24, 25, and 28 positively as shown in figure 5.2. The statements show that the students' needs are being met in as far as knowledge, and support from academic staff in industrial engineering institutions are concerned. The statements further support the notion that students are responding to the teaching institutions training approach and methodology; and thus fuelling the passion students have in industrial engineering. However, students still lack the initial support at the onset of their application and enrolment process. This is evident in statement 11 and 12. Students feel inadequately supported with laboratory practice within the institutions. On a good note, statement 23 shows that the students are fairly supported financially by guardians be it parents or financial aid.

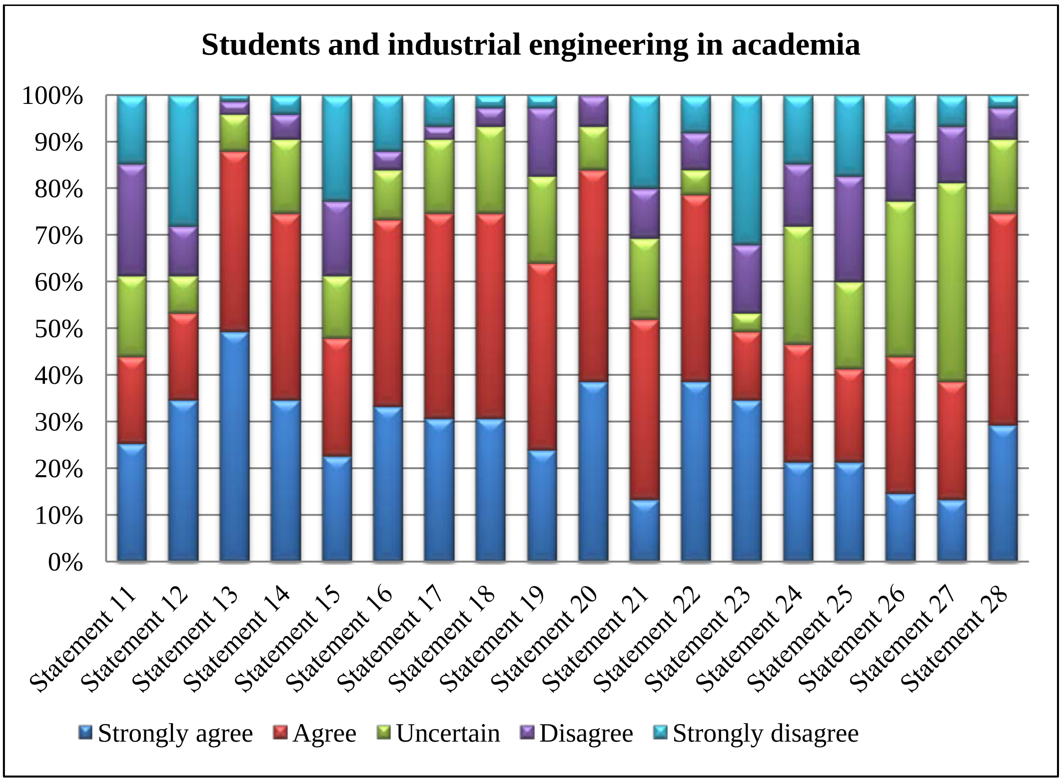


**Figure 5.2:** Stacked bar of students and industrial engineering in academia responses (Source: Own source)

- **Students: Statement 30 to 52 on quality in industrial engineering:** This area of the statement focused on identifying areas that limit or elevate industrial engineering's effectiveness from the student's perspective. Borrowing from the dimensions of quality, the statements focused on satisfying the value created through knowledge building, exposure and academic support that enhances and develops graduates who are adequately skilled, employable and competitive in industry. The analysis is based on variables statement 29 to 51 of figure 5.3. Looking at figure 5.3 below, the statements were positively answered denoting that industrial engineering is of immense value according to the students. They are well catered for as far as their academic needs, registration and application process. Knowledge development and industry participation are in alignment with industry needs and expectations.

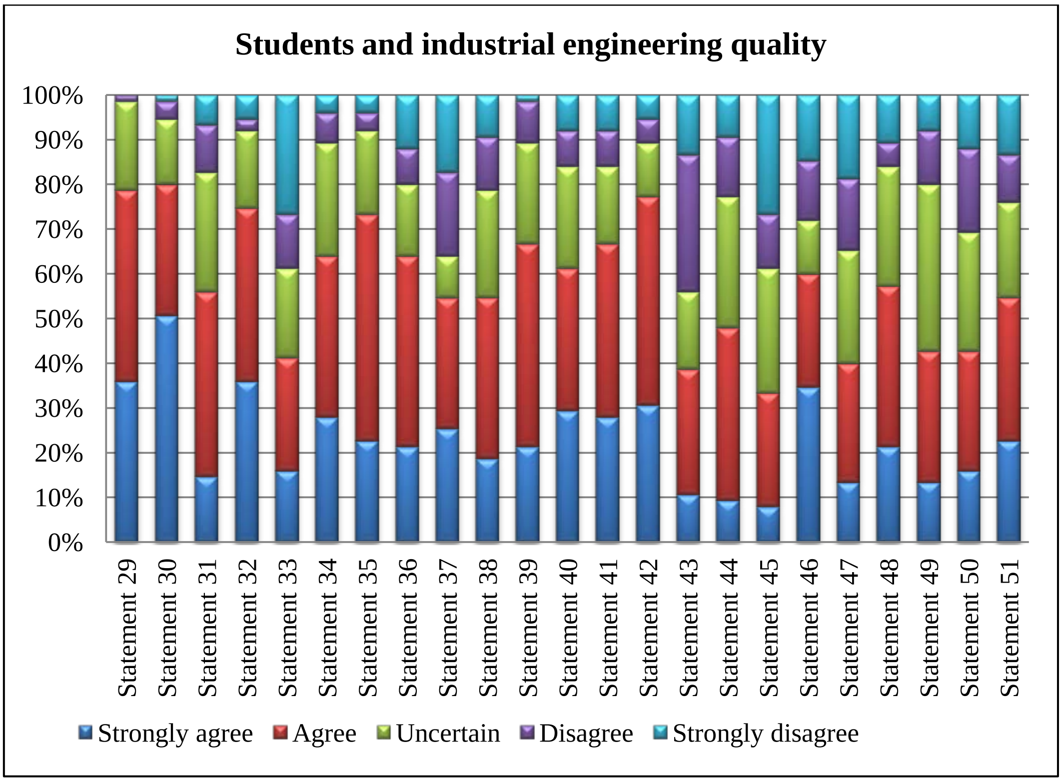


**Figure 5.3:** Stacked bar of students and industrial engineering quality responses (Source: Own source)

#### 5.3.3.2 Measurer of Students effectiveness and efficiency in meeting industry expectation

On the effectiveness vs. efficiency scale from figure 3.1, in Chapter 3, the inferences indicate that students fall in quadrant D of the scale meaning they have the right mindset on how effective industrial engineering is in adding value in industry but are still limited in identifying with the efficiency in application of the skill in as far as 'best fit' is concerned.

##### 5.3.3.3 Statements from the institutions (lecturers) environment

- **Institutions (Lecturers): Statement 1 to 10 on industrial engineering in industry:** This area of the statement focused on comprehending and clarifying the perspective the lecturers have on the role industrial engineering in industry, in adding value to the business and the impact it has on the quality of life through increasing productivity. The analysis is based on variables statement 1 to 10 of figure 5.4. From the graph in figure 5.4, the lectures answered in favoured of statements 1 to 9 demonstrating that there is a strong opinion on the positive level of passion and curiosity of industrial engineering in lecturers. Lecturers perceive industrial engineering as a key player in the industry and that a minimum qualification of a degree is marketable. Statements 3, 6 and 5 support the notion that industrial engineering influences the economy positively and should be capitalized as a strategic business move. Lecturers feel industrial engineering is a well-defined skill in industry and as in line with the industrial engineering academic goals. However, it is worth noting that in statement 10, there seems to be a need for lecturers to involve themselves more in industry related activities and collaborations in an effort to enhance and develop industrial engineering not only individually but for the student community and knowledge development.

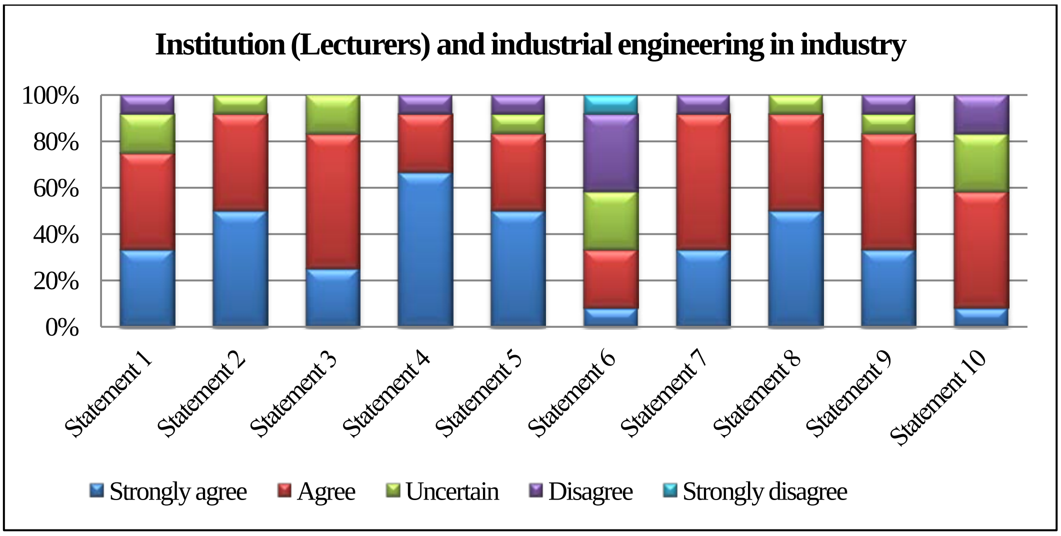


**Figure 5.4:** Stacked bar of institution (Lecturers) and industrial engineering in industry responses (Source: Own source)

- **Institutions (Lecturers): Statement 10 to 28 on industrial engineering in academia:** This area of the statement looks at the viewpoint the lecturer has, on the role industrial engineering plays in academia, in as far as adding value to the skill and the impact it has on the level of performance from graduating industrial engineering graduates. The statement is, how does the lecturers' support structure, motivation, passion, understanding and knowledge of the academic curriculum and environment that is industrial engineering, influence industry? In addition, how effective and efficient is the process to ensure industrial engineering skills are readily transferred and utilized in the right way to foster skills growth while meeting the needs and standards of industry? The analysis is based on variables statement 11 to 29 of figure 5.5. Under figure 5.5, statements 11 to 21 and 24 to 29 demonstrate this effectiveness and efficiency in the approaches adopted by the lectures. There is a highly encouraging outlook on the level of lecturers support and passion for the field of industrial engineering. It is worth noting that there is a consensus among lectures as to the importance of developing oneself in order to be of value to the teaching fraternity and student learning. Lecturers have a thirst for knowledge and aspirations of growth within their field of knowledge. It is conversely disappointing that fifty-eight percent of lecturers feel that their level of remuneration does not meet the level of work they are doing. Motivation however does not seem to hinge on this fact and does not seem to have a bearing or impinge on the level and quality of teaching lecturers proffer, further showing the level of commitment and passion the fraternity has. This is a point worth noting in that lecturers are self-motivated and independent in developing themselves further. This quality is an opportunity that needs to be appreciated in furthering industrial engineering academically and in other facets of society.

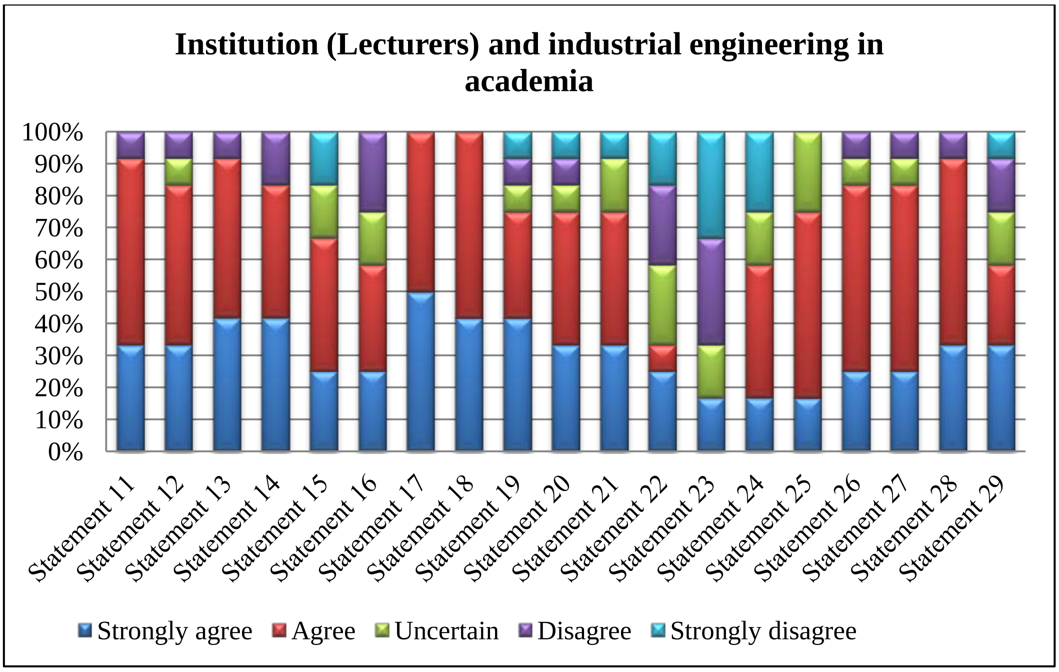


**Figure 5.5:** Stacked bar of institution (Lecturers) and industrial engineering in academia responses (Source: Own source)

- **Institutions (Lecturers): Statement 30 to 52 on quality in industrial engineering:** This area of the statement focused on identifying areas that limit or elevate industrial engineering's effectiveness from the lecture's perspective. Borrowing from the dimensions of quality, the statements focused on satisfying the value created through knowledge building, exposure and academic support that enhances and develops lecturers thereby graduates who are expected to be adequately skilled, employable and competitive in industry. The analysis is based on variables statement 30 to 52 of figure 5.6. There is an overwhelming support from lecturers in acknowledging that academic knowledge is innovative and of value. The quality and teaching approaches are considered dynamic and related to industry practices as viewed in statement 30 to 35 figure5.6. It is evident in statement 43 to 47 that involvement of external stakeholders in ensuring fairness and support for learners is encouraging. This level of support motivates students and lectures alike, ensuring that a competitive standard of education is maintained and developed.

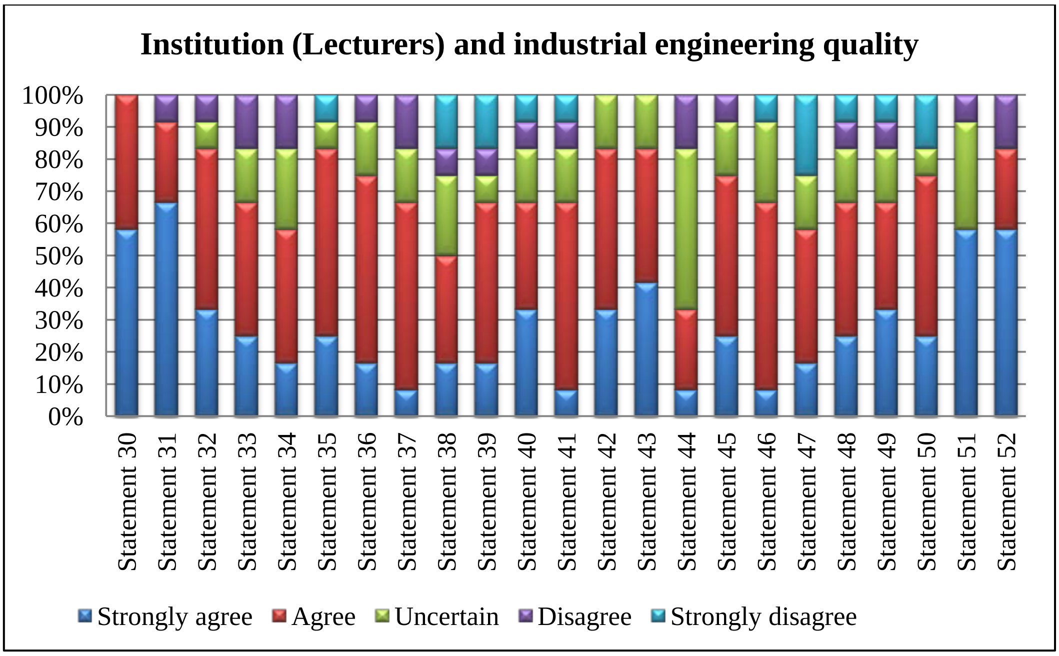


**Figure 5.6:** Stacked bar of institution (Lecturers) and industrial engineering quality responses (Source: Own source)

#### 5.3.3.4 Measurer of the Institutions effectiveness and efficiency in ensuring students meet industry expectation

On the effectiveness vs. efficiency scale figure 3.1 in Chapter 3, the institutions fall in quadrant A of the scale. This means that lecturers are adopting the right approach to teaching, motivating and developing the industrial engineering skill. Furthermore, lecturers are demonstrating various avenues of dynamically delivering the learning material by involving various facets of teaching from practice to innovative theory.

#### 5.3.3.5 Statements from the industry environment

- **South African Institute of Industrial Engineers SAIIE and the Engineering Council of South Africa ECSA on Industry: Statement 1 to 10 on industrial engineering in industry:** This area of the statement looks at the views industry has on the role industrial engineering in adding value to industry and sustaining this value. The analysis is based on variables statement 1 to 10 of figure 5.7. From the graph in figure 5.7, the industry favoured all statements positively except for statement 6, demonstrating that there is a deep sense of passion and interest of industrial engineering in industry. Industry confirms that industrial engineering plays a major innovative and productive role in the industry. Eighty two percent of industry participants confirm that a minimum of a bachelor's degree is adequate to allow an industrial engineering graduate to secure employment and position him or herself capable of adding value to the business to allow one to earn a place in the industry. Statement 6 focused on the awareness of industrial engineering regionally and nationally. This statement received a marginal response attesting the fact stated in the student survey as to the identity crisis faced by industrial engineering.

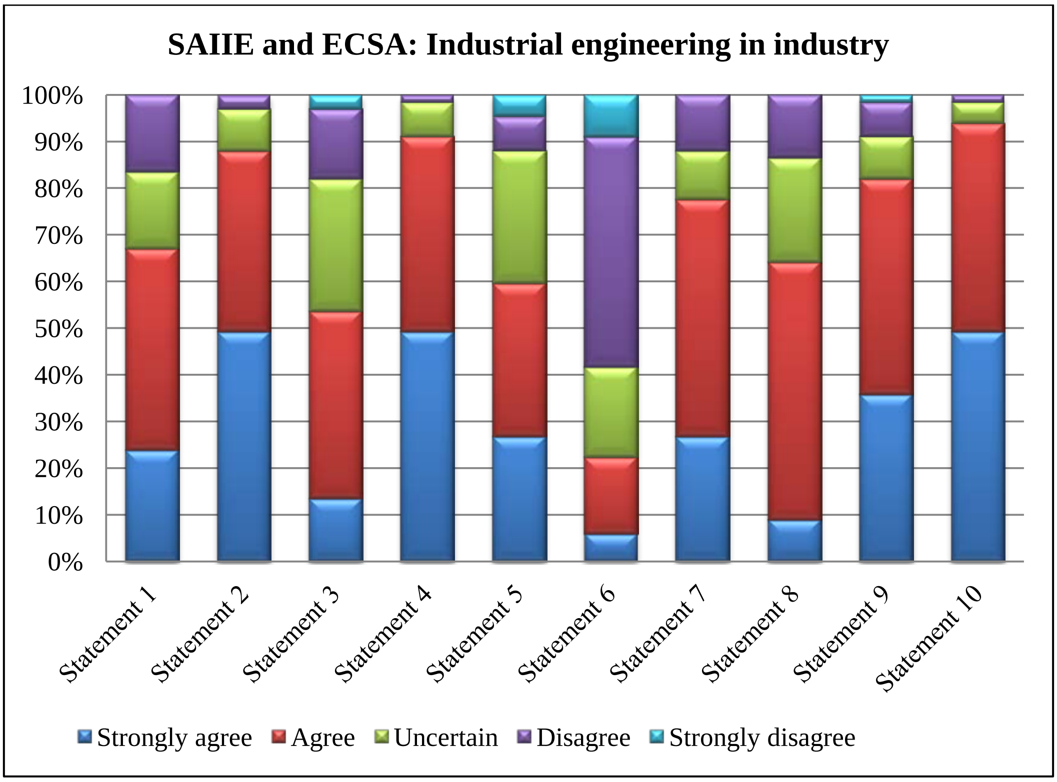


**Figure 5.7:** Stacked bar of SAIIE and ECSA: Industrial engineering in industry responses (Source: Own source)

- **South African Institute of Industrial Engineers SAIIE and the Engineering Council of South Africa ECSA on Industry: Statement 11 to 29 on industrial engineering in academia:.** This area of the statement looked at the perspective industry has on the role of industrial engineering in academia. Value is gained on the quality level of content delivered to students based on industry needs. The statement of relevancy and usefulness of content is of importance in this area of the statement. The analysis is based on variables statement 11 to 29 of figure 5.8. Industry answered statements 11 to 14 and 16 to 29 positively as seen in figure 5.8, in that industry is well versed, supportive and motivated academically on industrial engineering. Statement 15 however demonstrated that industry believes there is a need for practical learning in academia for new graduate industrial engineers leaving the academic programme. Interestingly, the students' survey concurs on this statement. This is important to note since one of the aims of this research is to delve into areas of possible improvements on the skills gap that further research may explorer. This statement contradicts the perception from the lectures survey. Lecturers' believe that academia offers the necessary teaching through practice and lab work. This contradiction between academia and the two other bodies i.e. the industry and students, may be due to lectures having poor industry interaction, inadequate industry feedback and other underlying reasons.

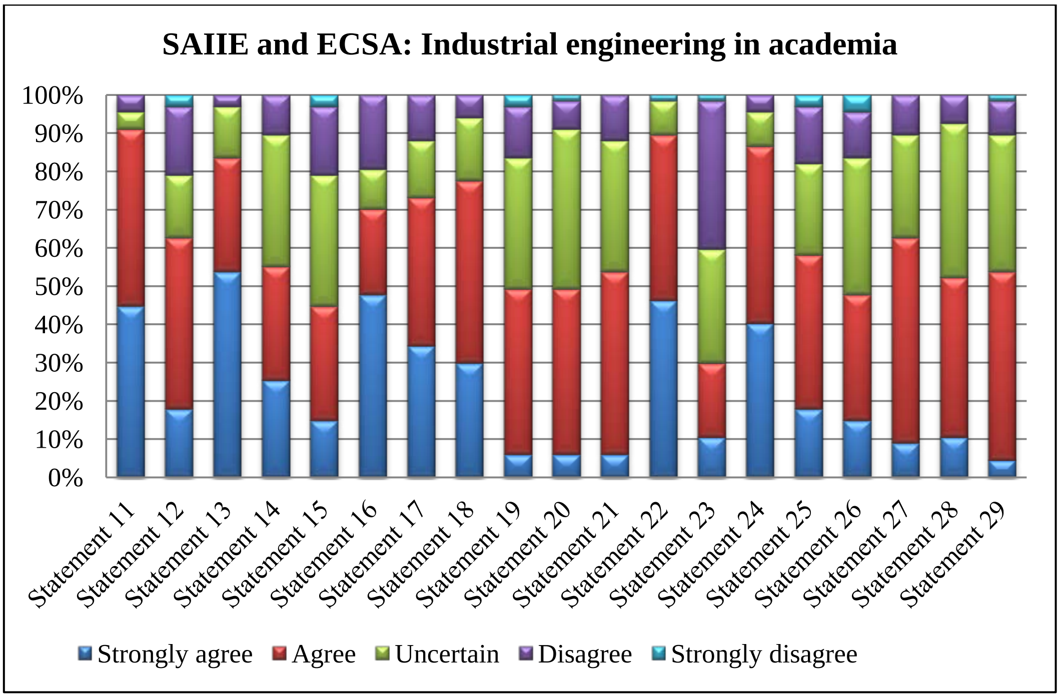


**Figure 5.8:** Stacked bar of SAIIE and ECSA: Industrial engineering in academia responses

(Source: Own source)

- **South African Institute of Industrial Engineers SAIIE and the Engineering Council of South Africa ECSA on Industry: Statement 30 to 52 on quality in industrial engineering:** This area of the statement focused on identifying areas that limit or elevate industrial engineering's quality standing from the eyes of industry. Borrowing from the dimensions of quality, the statements focused on satisfying the value created through knowledge building, exposure, and academic support that enhances and develops graduates who are adequately skilled, employable, and competitive in industry. Generally, industry supports the idea that industrial engineering has a quality component built into the skill. The statements explored in favour of the nature of the relevancy and lifecycle of the industrial engineering knowledge base, quality of lecturers and whether resource allocation adequately fosters productive learning environments. In addition, the statements delved into the checks and balances in place to ensure that a certain level of standard is maintained in the field of industrial engineering. The analysis is based on variables statement 30 to 52 of figure 5.9. It is well worth noting that statement 45 and 46 indicates that industry is actively involved in developing communication and practical interactions with academic and students through advisory boards in institutional programme development and interacting with students through lecture talks on industry activities.

#### 5.3.3.6 Measurer of the Industries effectiveness and efficiency in industrial engineering

On the effectiveness vs. efficiency scale in figure 3.1 Chapter 3, industry falls in quadrant A of the scale. This indicates that industry fairs well in its approach to developing industrial engineering towards students development. This is evident through its involvement in the growth of practice and knowledge of industrial engineering. The manner in which this approach emerges is considered efficient, through the curriculum development advisory bodies, industry visits and quality assurance audits managed by the Engineering Council of South Africa ECSA.

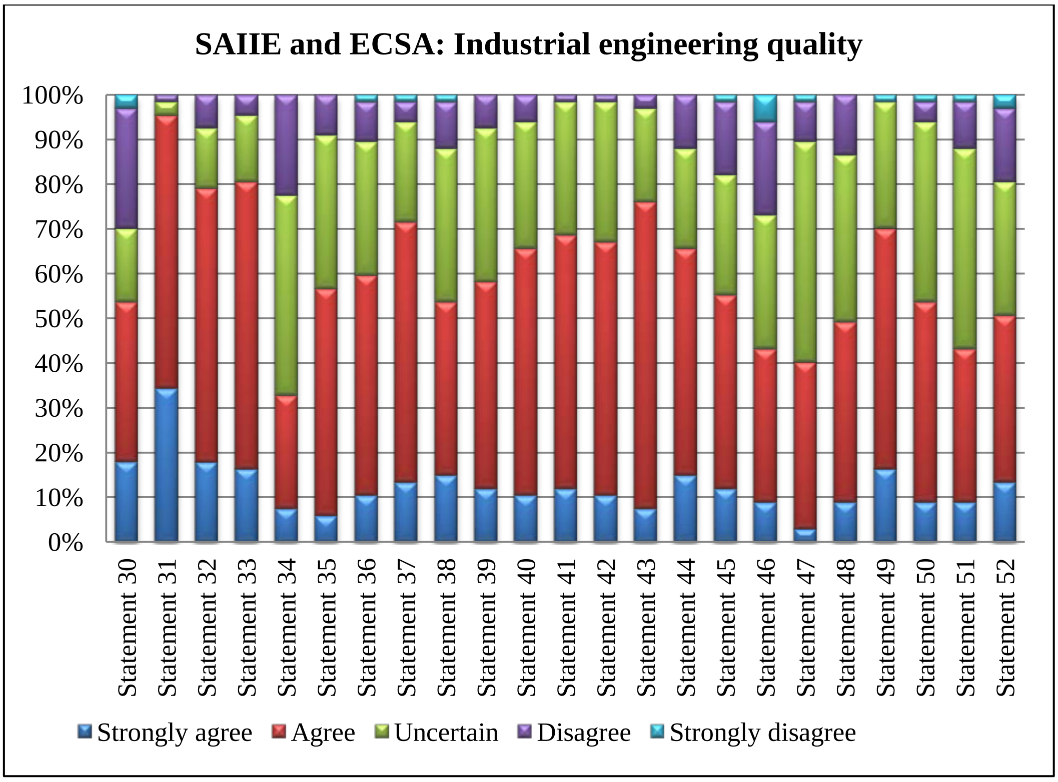


**Figure 5.9:** Stacked bar of SAIIE and ECSA: Industrial engineering quality responses (Source: Own source)

### 5.3.4 Measurements of student, industry, and academia

The measure of effectiveness and efficiency was discussed in figure 3.1 of Chapter 3. The inferences developed in this chapter in the statement analysis section, categorized the three sample groups into four of the quadrants as defined in the value model. This allows the researcher the opportunity to 'fit' and conclude as to the underlying cause of the perceived gap between students of industrial engineering and industry according to the stated problem statement.

From the analysis, it is evident that industry and academia are aligned as far as being 'effective' in promoting industrial engineering and being able to 'efficiently' deliver this skill to the students. The onus seems to lie with the students, as seen from the model. Being effective allows an individual the ability to achieve a task given certain pertinent tools and resources. However, achieving the task in the shortest time and in the least effort relies on how efficient one is capable of being. According to the outcome of the research, students are supported effectively with the tools and resources pertinent to attain value in industry / tasks given as industrial engineers, however the onus is on them as to how efficient the students are capable to utilize this skill in achieving this value in industry. The need here is to teach the students the ability to decide on the optimum route to follow in work performance. Several possibilities arise:

- Experience plays a major role as was highlighted by the industry survey in its expectations of academia in providing students with the much needed practical exposure to be able to decide on the most feasible approach to performing tasks in industry.
- Inclusion of case study teaching methodologies should be considered a priority.
- Lastly students motivation by ensuring a deeper sense of knowledge in industrial engineering back ground as highlighted by the students survey where students lacked the necessary direction and focus point on the onset of their industrial engineering learning programme.

### 5.3.5 Reliability testing

- **Reliability test employing Cronbach's alpha coefficient:**

A reliability measurement was conducted separately on every level of statements within the student, institution (lecturers) and industry survey based on the response given in the scale. The following lists the Cronbach's alpha coefficients determined for each sampled questionnaire:

**Table 5.2:** Cronbach's alpha coefficients for each sampled questionnaire (Source: Own source)

| Sample Questionnaire | Cronbach's alpha coefficient |
|---|---|
| Student Survey | 0.979 |
| Institution (Lecturer) Survey | 0.974 |
| Industry Survey | 0.989 |

Tavakol and Dennick (2011:54) iterated that Cronbach's alpha coefficients of 0.70 to 0.95 may be considered acceptable and that at times lower values in certain cases may be accepted. Based on the above-tabulated information, the student, institution and industry survey shows a raw variable Cronbach's alpha coefficient of 0.979, 0.974 and 0.989, which indicates that the questionnaires are considered reliable and consistent.

Tavakol and Dennick (2011:54) and George and Mallery (2003:231), further mention that as a general rule of thumb, alpha that is > .9 is excellent, > .8 is good, > .7 is acceptable, > .6 is questionable, > .5 is poor, and < .5 is unacceptable. Data sets with alpha that depicts values less than 0.70, may be attributed to underlying factors of multidimensional data or the length of the test survey among other reasons.

**Table 5.3:** Cronbach's alpha coefficient for student questionnaire (Source: Own source)

| Statements Category | Cronbach's Alpha Coefficient |
|---|---|
| **CATEGORY I: INDUSTRIAL ENGINEERING IN INDUSTRY** | |
| Statement 1 – Statement 10 | 0.880 |
| **CATEGORY II: INDUSTRIAL ENGINEERING IN ACADEMIA** | |
| Statement 11 – Statement 28 | 0.945 |
| **CATEGORY III: QUALITY IN INDUSTRIAL ENGINEERING** | |
| Statement 29 – Statement 51 | 0.964 |
| **Overall Cronbach's Alpha Coefficient** | |
| Cronbach's Alpha Coefficient for raw variables | 0.979 |

**Table 5.4:** Cronbach's alpha coefficient for institutions (lectures) questionnaire (Source: Own source)

| Statements Category | Cronbach's Alpha Coefficient |
|---|---|
| **CATEGORY I: INDUSTRIAL ENGINEERING IN INDUSTRY** | |
| Statement 1 – Statement 10 | 0.948 |
| **CATEGORY II: INDUSTRIAL ENGINEERING IN ACADEMIA** | |
| Statement 11 – Statement 29 | 0.967 |
| **CATEGORY III: QUALITY IN INDUSTRIAL ENGINEERING** | |
| Statement 30 – Statement 52 | 0.969 |
| **Overall Cronbach's Alpha Coefficient** | |
| Cronbach's Alpha Coefficient for raw variables | 0.974 |

**Table 5.5:** Cronbach's alpha coefficient for industry questionnaire (Source: Own source)

| Statements Category | Cronbach's Alpha Coefficient |
|---|---|
| **CATEGORY I: INDUSTRIAL ENGINEERING IN INDUSTRY** | |
| Statement 1 – Statement 10 | 0.928 |
| **CATEGORY II: INDUSTRIAL ENGINEERING IN ACADEMIA** | |
| Statement 11 – Statement 29 | 0.963 |
| **CATEGORY III: QUALITY IN INDUSTRIAL ENGINEERING** | |
| Statement 30 – Statement 52 | 0.989 |
| **Overall Cronbach's Alpha Coefficient** | |
| Cronbach's Alpha Coefficient for raw variables | 0.989 |

- **The Spearman's rank test:**

Revisiting the research statement addressed at the beginning of this study, the statement stated that 'there is a lack of adequate communication between industry and institutions, the result of which, the skills level and academic qualification attained by graduating industrial engineers do not meet industry expectations'. The test was applied to determine the extent or the degree of correlation between industry skills expected of graduate industrial engineers and the academic ability of students, vis-a-viz higher learning institutions to meet this need.

The Spearman rank test for correlation (Singletary, Hill, Smith, and Corcoran, 2004), were calculated to determine whether there is a relationship between the following:

- Industrial engineering students are adequately equipped to meet industry expectations.
- The institutions are capable of skilling industrial engineering students to meet industry need.

The following shows the results derived from the Spearman Rank correlation test

**Table 5.6:** Spearman rank correlation for students (Source: Own source)

| **Spearman rank correlation**<br><br>**P-value** | Industrial engineering students are adequately equipped to meet industry expectations. |
|---|---|
| The institution is capable of skilling industrial engineering students to meet industry need. | R = -0.383<br><br>p value < 0.005 |

**Table 5.7:** Spearman rank correlation for industry (lecturer) (Source: Own source)

| **Spearman rank correlation /**<br><br>**P-value** | Industrial engineering students are adequately equipped to meet industry expectations. |
|---|---|
| The institution is capable of skilling industrial engineering students to meet industry need. | R = -0.376<br><br>p value < 0.006 |

From the results shown above in table 5.6 and 5.10 for the student's and institution's (lecture's) spearman rank correlation, the following was concluded:

- **Student spearman rank correlation on the two statements:** There seems to be a statistically significant positive relationship between the two statements.
- **Industry spearman rank correlation on the two statements:** There seems to be a statistically significant positive relationship between the two statements

# CHAPTER 6: CONCLUSION

## 6.1 INTRODUCTION

The researcher conceptualises the information presented in this study, by taking a retrospective look at key areas of the research. In setting the stage, Statistics South Africa (South Africa, 2010:4.2-4.7), highlighted that during the year 2008 and 2009, South Africa and the global community, experienced a major economic slump putting most manufacturing and other key segments of the economy under duress; with poverty, unemployment and skills shortage due to poor productivity being felt expansively. The government and business communities at large realized the necessity for skills development across the major economic sectors in order to resuscitate the failing economy. The solutions lay in organisations re-evaluating their current operational strategies by streamlining their organisations and adopting aggressive lean and cost saving approaches in order to remain competitive.

Two things became apparent; one was the need for skills growth and two the need for a cost cutting, cost saving and optimisation skill, a skill descriptively and applicably seen in industrial engineering. The role of graduate institutions facilitating the growth of the Human Capital Development in the work environment has become a critical factor in South Africa, aiming at improving the productivity and economic growth of the country.

## 6.2 RESEARCH ENVIRONMENT

In this study, the focus confined itself on three main areas of discussion, one being the institution environment with the students and lecture relationship explored and three being the Work environment. The study highlighted the influence the three environments have on industrial engineering skills and competencies attained by university student graduates and how this ultimately creates a way out for the South African economy.

Looking back at Chapter 1, the researcher introduced the reader to the scope of the research study covering in summary the procedure the study would entail and proceeded to discuss in Chapter 2 the research environment, in as far as the three sample groups' (i.e. the student, the industry and the institution of higher learning) holistic perspective was concerned. In Chapter 3, under literature review, the research went through current information regarding the issue of industrial engineering with specific focus levelled at the following:

- Quality, TQM, and industrial engineering, and education.
- Skills level and its impact on productivity.
- Industrial engineering and its value to industry.
- Industrial expectations of an industrial engineering graduate.
- The higher education bodies responsible for curriculation of industrial engineering as a career choice.

In Chapter 4, the design and methodology of the research, elaborating on various means the study would capture and analyze the data was discussed. Successively Chapter 5 informed the reader on the data analysis and interpretation of results gleaned from the results obtained. The researcher concluded the study by making inferences pertinent to the variables under study.

## 6.3 A RETROSPECT OF THE RESEARCH PROBLEM AND QUESTION STATEMENT

The research problem stated thus; 'there is a lack of adequate communication between industry and institutions, the result of which, the skills level and academic qualification attained by graduating industrial engineers do not meet industry expectations'.

This followed a research question, which read as follows; "Are the graduate industrial engineers able to meet the minimum demands and skills level expected by the relevant industrial engineering industry?" Through a series of objectives, the researcher was able to develop several investigative statements, which formed the basis of the literature study. Bridging the assumed gap between the student's skills level acquired from academic knowledge and the application of this skill within the industrial engineering environment was investigated through several surveys to meet the objectives as stated within Chapter 1 of the study.

## 6.4 RETROSPECT OF THE INVESTIGATIVE STATEMENTS

The investigative statements researched in support of the research statement were noted as follows:

- What are the significant roles played by industrial engineering graduates in industry?
- What is the minimum skills level of a graduate industrial engineer?
- What is the existing academic national qualification framework for industrial engineering curricula, as defined by SAQA?
- How to ensure high quality levels of industrial engineering graduates in order to meet industry expectations?

The aforementioned statements were investigated further to determine the significant roles played by industrial engineering in industry. The researchers' discussions on the areas favoured by the industrial engineering skill purposely elucidates on the relevance of industrial engineering to the economic crisis that ails South Africa. Namely five key roles industrial engineers need to play a strong part in i.e. enterprise engineering, systems engineering, operations management, applied industrial engineering and engineering management. In addition to this, the researcher is able to identify the minimum skills level of a qualified graduate industrial engineer as seen by industry and as highlighted in Chapter 3 according to Chikumba(2009:30-41) i.e. skills in operations management, operations research, engineering management and economics, supply chain management and logistics, simulation and modelling, manufacturing systems and engineering, human factors engineering and ergonomics, quality and production planning and control, materials management, performance management, operations management, problem-solver, innovator, coordinator, and change agent among others, including the existing academic national qualification framework for industrial engineering curriculum, as defined by SAQA. In discussing these two broad areas of literature, the researcher is able to show the alignment of the two components i.e. curriculum requirements and the skills level of the industrial engineer thereby narrowing the stated gap in the research question statement. It is however important to mention that alignment of the two is of no consequence if value is not proffered. The study proceeded to find out an effective mechanism to ensure high quality levels of industrial engineers capable of meeting industry expectations in a cross section study of what it means to have quality represented in industrial engineering.

Just as any other organisation that utilizes quality to gain optimum throughput, higher education requires a quality component. Viewing industrial engineering in institutions of higher learning as a system with interrelated components, with the 'customer' being the product of interest such as the graduate industrial engineer, quality becomes an aspect that one is hard pressed to ignore just as in any other manufacturing process. Chikumba (2009:33), iterates that the organisational transformation model, emphasizes that understanding organisations as a model is important for successful execution of corporate strategy and that viewing the organisation as a transformation process, which satisfies customer needs through maximizing value added to inputs producing outputs through routine and repetitive or programmable decisions is important. In defining value, the dimensions of quality should not be ignored; value accrues through the creation of the products' function. This ideology is better described mathematically as (Moll, 1998:310-322):

$$VALUE = \frac{\text{FUNCTIONALITY (as a Product or Service or System)}}{\text{COST}}$$

$$\therefore VALUE = \frac{\text{QUALITY, SPEED, and FLEXIBILITY (Drivers of value)}}{\text{RISK, WASTE, and CASH FLOW (Drivers of value)}}$$

**Figure 6.1:** Operational value drivers (Moll, 1998:322)

Moll (1998:309-315) discusses the value formulae in figure 6.1 terming it as the ‘operational value drivers’ derived as the ratio of performance or function (output) vs. cost (input). The magnitude of value is thus determined by a change in the two variables functionality and cost. A positive magnitude is denoted as a result of an increase in the functionality of the product / service with a subsequent decrease in the cost input variable influencing a positive value change. Moll further iterates the factors that influence this value as, quality, speed, flexibility, risk, waste and cash flow identical to the dimensions of quality i.e. quality speed flexibility expenditure risk and waste.

The three main groups responsible for creating this value are considered in this study as falling within three domains one the industry, two the institutions of higher learning and three the student. The study measured these groups against the effectiveness and efficiency model described in Chapter 4 and 5. Being effective allows an individual the ability to achieve a task given certain pertinent tools and resources. However, achieving the task in the shortest time and in the least effort relies on how efficient one is.

## 6.5 DATA COLLECTION AND ANALYSIS OF RESULTS

Three separate questionnaires similar in design and nature were developed for each subgroup. A distinction per questionnaire was intentionally built in through re-structuring each survey according to the environment suitable to the sub-group in question. Each questionnaire was broken into three distinct sections covering three prescribed environments of industrial engineering. Firstly the Academic environment – seeking the perception of industrial engineering in as far as knowledge understanding and creation, secondly industrial / work environment seeking the perception of industrial engineering’s impact in the business organisation and lastly quality environment of industrial engineering seeking the perceived level of ‘value’ understood in this engineering skill. Within the ambit of Chapter 5, statistical inferences were drawn from three Likert type scale questionnaires developed in Chapter 4. Using a sample group of one hundred and fifty four participants from all three groups, the study was administered in form of an online and manual survey in conjunction with several interview sessions.

A study is not conclusive if one cannot measure the variables in question. Two models were introduced into the study; one being the relationship model in figure 4.3 showing the three key role players described as the sample groups and the effectiveness and efficiency value model introduced in Chapter 3, figure 3.1. The relationship model used clarified the relationships between the three groups while the effectiveness and efficiency model measured the gap existing between the two groups. The measure of effectiveness and efficiency depicted the level of value that students need to attain employability and value in industry. The inferences developed in Chapter 5 under the statement analysis section, categorized the three sample groups into two of the four quadrants of the effectiveness and efficiency model. From the analysis, it is evident that industry and academia are in accord as far as being effective in industrial engineering approach and being able to efficiently deliver this skill to the students. The students' 'fit' falls within the effectiveness and inefficient quadrant 'D' as shown within figure 3.1 in Chapter 3.

It is thus evident from figure 3.1 in Chapter 3, that students have the necessary resources attained through their academic programmes and the adequate interaction with industry to be effective at applying the attained knowledge and skill in industry. However, how efficient and capable the students are at utilizing this skill in achieving this value in industry is a significant issue requiring further research.

## 6.6 DISCUSSIONS, RECOMMENDATIONS AND CONCLUSION

### 6.6.1 Discussions

The inferences from the information gleaned from the three surveys administered to the students, institutions, and industry bodies are as follows:

- Students have the right mindset on how effective industrial engineering is in adding value in industry but are still limited in identifying with the efficiency in application of the skill in as far as ‘best fit’ is concerned. Efficiency in this case means the application of skills taught at universities of higher education.

- Lecturers are adopting the right approach to teaching, motivating and developing the industrial engineering skill. Furthermore, lecturers are demonstrating various avenues of dynamically delivering the learning material by involving various facets of teaching from practice to innovative theory.
- Industry fairs well in its approach to developing skilled industrial engineering students in an effort to spearhead industrial engineering as the forefront of South Africa’s’ economic growth and sustainability. This is evident through its involvement in the growth of practice and knowledge of industrial engineering. The manner in which this approach emerges is considered efficient, through the curriculum development advisory bodies, industry visits, and quality assurance audits managed by the various quality assurance bodies as gleaned from the survey.

### 6.6.2 Recommendations

From observations collected in the research, the following may be addressed towards a solution to the inefficiency faced by the students:

- **Embedding of TQM principles into the learning process at universities:** Taking a look back at Chapter 3, according to Ho and Wearn (1996:37), the discussion of TQM as a management philosophy and company practice, which aim to harness the human and material resources of an organisation, in the most effective way to achieve the objectives of the organisation, refer to the principles and tools surrounding total quality management as one way of managing institutions that provide industrial engineering as a learning programme. The opportunity is seen in develop valuable graduates, by emphasising on the human quality aspect as a resource that can be managed effectively towards efficiency.
- **A practical, hands-on approach** plays a major role as was highlighted by the industry survey in its expectations of academia in providing students with the much-needed practical exposure to be able to decide on the most feasible

approach to performing tasks in industry. It is increasingly becoming difficult to cut a clear distinct line around the discipline that is industrial engineering. Due to various generic skills that have mushroomed over time that incorporate and apply a number of industrial engineering practices and skills, such as continuous improvement being a part of management practices and newly created professions such as change managers among others, the industrial engineering skill is becoming a grey discipline, creating more confusion within industrial engineering student learners The need to clarify the role of industrial engineering within industry and through the inclusion of case study teaching methodologies in academia that focus on specific application of industrial engineering skills to specific problem areas should be considered a priority.

- **Developing and improving the students motivation by instilling a deeper sense camaraderie** through development of industrial engineering societies within the institutions and building the students knowledge of industrial engineering back ground as highlighted by the students survey, where students lacked the necessary direction and focus point at the onset of their industrial engineering learning course.

### 6.6.3 Conclusion

The skills shortage remains a topical issue for South Africa. The research has at some level; clearly demonstrate the need to further develop innovative academic approaches in developing better-equipped graduates through the following:

- Attaining value in students; through the introduction of industrial engineering societies in institutions of higher learning. This will ultimately fuel interest and develop industrial engineering.
- Support of lecturing staff and institutions of higher learning through research, knowledge development and enterprising projects pertinent to current industry needs
- Building on the current communication that exists between the industry and institutions of higher learning through advisory boards among other forums by

enriching the current one way feedback (industry to academia), to a two way communication i.e. involving lectures in industry decision making process of company strategies.

- Influencing institutions of higher learning to stimulate young minds towards application-based thinking approaches and enterprise-based methodologies. This will cultivate a productive business environment that will benefit all supply chain stakeholders and in so doing uplift the economy.

In order to remain competitive, industrial engineering needs to position itself where overall value is the essence of performance; achieved through effective and efficient problem solving approaches. In so doing industrial engineering will be better placed, understood, and accepted by society.

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# ANNEXURE A

## Descriptive statistics of responses from students

**NB: Percentage totals were rounded off.**

| Variables | Categories | Frequency | Percentage out of total |
|---|---|---|---|
| Students Questionnaire | | | |
| **CATEGORY I: INDUSTRIAL ENGINEERING IN INDUSTRY** | | | |
| **1.** I have a clear understanding of industrial engineering as a branch of engineering. | Strongly agree | 21 | 28% |
| | Agree | 46 | 61% |
| | Uncertain | 6 | 8% |
| | Disagree | 2 | 3% |
| | Strongly disagree | 0 | 0% |
| **2.** I am curious about industrial engineering. | Strongly agree | 36 | 48% |
| | Agree | 31 | 41% |
| | Uncertain | 7 | 9% |
| | Disagree | 1 | 1% |
| | Strongly disagree | 0 | 0% |
| **3.** I know clearly, where industrial engineering originated from in the South African Industry. | Strongly agree | 3 | 4% |
| | Agree | 14 | 19% |
| | Uncertain | 31 | 41% |
| | Disagree | 17 | 23% |
| | Strongly disagree | 10 | 13% |
| **4.** Industrial engineering plays a key role in the manufacturing and service industry in South Africa. | Strongly agree | 32 | 43% |
| | Agree | 33 | 44% |
| | Uncertain | 7 | 9% |
| | Disagree | 3 | 4% |
| | Strongly disagree | 0 | 0% |

| Variables | Categories | Frequency | Percentage out of total |
|---|---|---|---|
| **5.** The South African economy is influenced by the role played by industrial engineers in Industry. | Strongly agree | 18 | 24% |
| | Agree | 31 | 41% |
| | Uncertain | 15 | 20% |
| | Disagree | 9 | 12% |
| | Strongly disagree | 2 | 3% |
| **6.** There is an adequate awareness of industrial engineering by the Industry regionally and nationally. | Strongly agree | 4 | 5% |
| | Agree | 20 | 27% |
| | Uncertain | 27 | 36% |
| | Disagree | 18 | 24% |
| | Strongly disagree | 6 | 8% |
| **7.** I have a student to mentor / role model relationship with an industrial engineer in Industry. | Strongly agree | 9 | 12% |
| | Agree | 16 | 21% |
| | Uncertain | 10 | 13% |
| | Disagree | 24 | 32% |
| | Strongly disagree | 16 | 21% |
| **8.** My institution is capable of skilling me to becoming a productive industrial engineer. | Strongly agree | 27 | 36% |
| | Agree | 29 | 39% |
| | Uncertain | 12 | 16% |
| | Disagree | 6 | 8% |
| | Strongly disagree | 1 | 1% |
| **9.** I need a Bachelors degree and above in industrial engineering to become adequately skilled to perform well | Strongly agree | 39 | 52% |
| | Agree | 26 | 35% |
| | Uncertain | 2 | 3% |
| | Disagree | 4 | 5% |
| | Strongly | 4 | 5% |

| Variables | Categories | Frequency | Percentage out of total |
|---|---|---|---|
| in Industry. | disagree | | |
| **10.** I plan to pursue industrial engineering related projects and activities in Industry. | Strongly agree | 32 | 43% |
| | Agree | 24 | 32% |
| | Uncertain | 9 | 12% |
| | Disagree | 8 | 11% |
| | Strongly disagree | 2 | 3% |
| **CATEGORY II: INDUSTRIAL ENGINEERING IN ACADEMIA** | | | |
| **11.** I understood what I wanted to do before completing my final high school qualification. | Strongly agree | 19 | 25% |
| | Agree | 14 | 19% |
| | Uncertain | 13 | 17% |
| | Disagree | 18 | 24% |
| | Strongly disagree | 11 | 15% |
| **12.** I chose industrial engineering as my first choice of study. | Strongly agree | 26 | 35% |
| | Agree | 14 | 19% |
| | Uncertain | 6 | 8% |
| | Disagree | 8 | 11% |
| | Strongly disagree | 21 | 28% |
| **13.** I am passionate about learning industrial engineering. | Strongly agree | 37 | 49% |
| | Agree | 29 | 39% |
| | Uncertain | 6 | 8% |
| | Disagree | 2 | 3% |
| | Strongly disagree | 1 | 1% |
| **14.** Industrial engineering is a branch of engineering that I have come to or | Strongly agree | 26 | 35% |
| | Agree | 30 | 40% |
| | Uncertain | 12 | 16% |

| Variables | Categories | Frequency | Percentage out of total |
| --- | --- | --- | --- |
| coming to have a clear understanding of. | Disagree | 4 | 5% |
| | Strongly disagree | 3 | 4% |
| **15.** My institution has the practical capacity to teach me industrial engineering using labs, workshops, industry visits and among others | Strongly agree | 17 | 23% |
| | Agree | 19 | 25% |
| | Uncertain | 10 | 13% |
| | Disagree | 12 | 16% |
| | Strongly disagree | 17 | 23% |
| **16.** I decided on my current institution of learning as my first choice to pursue my desired qualification. | Strongly agree | 25 | 33% |
| | Agree | 30 | 40% |
| | Uncertain | 8 | 11% |
| | Disagree | 3 | 4% |
| | Strongly disagree | 9 | 12% |
| **17.** Industrial engineering qualification comes in various NQF levels that I fully understand e.g. National diploma, B.Tech, B degree among and others. | Strongly agree | 23 | 31% |
| | Agree | 33 | 44% |
| | Uncertain | 12 | 16% |
| | Disagree | 2 | 3% |
| | Strongly disagree | 5 | 7% |
| **18.** I fully understand what my curriculum expects of me. | Strongly agree | 23 | 31% |
| | Agree | 33 | 44% |
| | Uncertain | 14 | 19% |
| | Disagree | 3 | 4% |
| | Strongly disagree | 2 | 3% |

| Variables | Categories | Frequency | Percentage out of total |
|---|---|---|---|
| **19.** My institution is offering me qualified teachers and teaching aids to allow me to fully understand the theory and practice of industrial engineering. | Strongly agree | 18 | 24% |
| | Agree | 30 | 40% |
| | Uncertain | 14 | 19% |
| | Disagree | 11 | 15% |
| | Strongly disagree | 2 | 3% |
| **20.** My institution makes me believe that my career choice can make a difference in my life and the economy. | Strongly agree | 29 | 39% |
| | Agree | 34 | 45% |
| | Uncertain | 7 | 9% |
| | Disagree | 5 | 7% |
| | Strongly disagree | 0 | 0% |
| **21.** I have the full support I need from my teaching instructors. | Strongly agree | 10 | 13% |
| | Agree | 29 | 39% |
| | Uncertain | 13 | 17% |
| | Disagree | 8 | 11% |
| | Strongly disagree | 15 | 20% |
| **22.** I feel personally encouraged to learn industrial engineering. | Strongly agree | 29 | 39% |
| | Agree | 30 | 40% |
| | Uncertain | 4 | 5% |
| | Disagree | 6 | 8% |
| | Strongly disagree | 6 | 8% |
| **23.** I am currently on a bursary or financial aid and not supported by | Strongly agree | 26 | 35% |
| | Agree | 11 | 15% |
| | Uncertain | 3 | 4% |
| | Disagree | 11 | 15% |

| Variables | Categories | Frequency | Percentage out of total |
|---|---|---|---|
| my guardian or myself. | Strongly disagree | 24 | 32% |
| **24.** My finances are adequate to cover my full academic tuition and living standards. | Strongly agree | 16 | 21% |
| | Agree | 19 | 25% |
| | Uncertain | 19 | 25% |
| | Disagree | 10 | 13% |
| | Strongly disagree | 11 | 15% |
| **25.** I am fully supporting myself through my industrial engineering studies. | Strongly agree | 16 | 21% |
| | Agree | 15 | 20% |
| | Uncertain | 14 | 19% |
| | Disagree | 17 | 23% |
| | Strongly disagree | 13 | 17% |
| **26.** I know and understand the South African Qualifications Framework. | Strongly agree | 11 | 15% |
| | Agree | 22 | 29% |
| | Uncertain | 25 | 33% |
| | Disagree | 11 | 15% |
| | Strongly disagree | 6 | 8% |
| **27.** I understand the various industrial engineering NQF level descriptors | Strongly agree | 10 | 13% |
| | Agree | 19 | 25% |
| | Uncertain | 32 | 43% |
| | Disagree | 9 | 12% |
| | Strongly disagree | 5 | 7% |
| **28.** My course structure was fully explained to me through the subject | Strongly agree | 22 | 29% |
| | Agree | 34 | 45% |
| | Uncertain | 12 | 16% |

| Variables | Categories | Frequency | Percentage out of total |
|---|---|---|---|
| Study Guide. | Disagree | 5 | 7% |
| | Strongly disagree | 2 | 3% |
| **CATEGORY III: QUALITY IN INDUSTRIAL ENGINEERING** | | | |
| **29.** The definition of industrial engineering is quality in itself. | Strongly agree | 27 | 36% |
| | Agree | 32 | 43% |
| | Uncertain | 15 | 20% |
| | Disagree | 1 | 1% |
| | Strongly disagree | 0 | 0% |
| **30.** Industrial engineering is an innovative, knowledge based and enterprise based thinking process. | Strongly agree | 38 | 51% |
| | Agree | 22 | 29% |
| | Uncertain | 11 | 15% |
| | Disagree | 3 | 4% |
| | Strongly disagree | 1 | 1% |
| **31.** The current teaching material in South Africa is relevant to the industrial engineering qualification in South Africa. | Strongly agree | 11 | 15% |
| | Agree | 31 | 41% |
| | Uncertain | 20 | 27% |
| | Disagree | 8 | 11% |
| | Strongly disagree | 5 | 7% |
| **32.** The South African Industry objectives e.g. improving productivity and among others is in line with what is taught at my institution. | Strongly agree | 27 | 36% |
| | Agree | 29 | 39% |
| | Uncertain | 13 | 17% |
| | Disagree | 2 | 3% |
| | Strongly disagree | 4 | 5% |

| Variables | Categories | Frequency | Percentage out of total |
|---|---|---|---|
| **33.** We have regular input (e.g. forums) from Industry regarding the impact industrial engineering has on Industry performance. | Strongly agree | 12 | 16% |
| | Agree | 19 | 25% |
| | Uncertain | 15 | 20% |
| | Disagree | 9 | 12% |
| | Strongly disagree | 20 | 27% |
| **34.** The level of teaching is adequate to skill the current industrial engineer. | Strongly agree | 21 | 28% |
| | Agree | 27 | 36% |
| | Uncertain | 19 | 25% |
| | Disagree | 5 | 7% |
| | Strongly disagree | 3 | 4% |
| **35.** The material taught to me in class is well understood and adequately links with the skills necessary to work in Industry. | Strongly agree | 17 | 23% |
| | Agree | 38 | 51% |
| | Uncertain | 14 | 19% |
| | Disagree | 3 | 4% |
| | Strongly disagree | 3 | 4% |
| **36.** When applying to study industrial engineering at my institution, the process was clear and easy. | Strongly agree | 16 | 21% |
| | Agree | 32 | 43% |
| | Uncertain | 12 | 16% |
| | Disagree | 6 | 8% |
| | Strongly disagree | 9 | 12% |
| **37.** The registration procedure and requirements was run smoothly and not | Strongly agree | 19 | 25% |
| | Agree | 22 | 29% |
| | Uncertain | 7 | 9% |
| | Disagree | 14 | 19% |

| Variables | Categories | Frequency | Percentage out of total |
|---|---|---|---|
| stressful. | Strongly disagree | 13 | 17% |
| **38.** I have a healthy and conducive study environment. | Strongly agree | 14 | 19% |
| | Agree | 27 | 36% |
| | Uncertain | 18 | 24% |
| | Disagree | 9 | 12% |
| | Strongly disagree | 7 | 9% |
| **39.** Information on industrial engineering at the institutions' classes, teachers, and the library is readily available. | Strongly agree | 16 | 21% |
| | Agree | 34 | 45% |
| | Uncertain | 17 | 23% |
| | Disagree | 7 | 9% |
| | Strongly disagree | 1 | 1% |
| **40.** The evaluation process conducted for industrial engineering at the institution is fair and unbiased. | Strongly agree | 22 | 29% |
| | Agree | 24 | 32% |
| | Uncertain | 17 | 23% |
| | Disagree | 6 | 8% |
| | Strongly disagree | 6 | 8% |
| **41.** I have adequate access to my teaching instructors. | Strongly agree | 21 | 28% |
| | Agree | 29 | 39% |
| | Uncertain | 13 | 17% |
| | Disagree | 6 | 8% |
| | Strongly disagree | 6 | 8% |
| **42.** The institution offers other means of developing my studies | Strongly agree | 23 | 31% |
| | Agree | 35 | 47% |
| | Uncertain | 9 | 12% |

| Variables | Categories | Frequency | Percentage out of total |
|---|---|---|---|
| through e.g. tutor, tutorials, projects and among others | Disagree | 4 | 5% |
| | Strongly disagree | 4 | 5% |
| **43.** I am able to interact with institutions and groups internally and externally to develop my knowledge of industrial engineering e.g. discussion groups | Strongly agree | 8 | 11% |
| | Agree | 21 | 28% |
| | Uncertain | 13 | 17% |
| | Disagree | 23 | 31% |
| | Strongly disagree | 10 | 13% |
| **44.** My institution interacts with industry stakeholders to develop industrial engineering to meet current industry standards. | Strongly agree | 7 | 9% |
| | Agree | 29 | 39% |
| | Uncertain | 22 | 29% |
| | Disagree | 10 | 13% |
| | Strongly disagree | 7 | 9% |
| **45.** My institution organises research, student projects, competitions, among others funded by Industry to bring awareness to industrial engineering and the students studying the course. | Strongly agree | 6 | 8% |
| | Agree | 19 | 25% |
| | Uncertain | 21 | 28% |
| | Disagree | 9 | 12% |
| | Strongly disagree | 20 | 27% |
| **46.** My family is intimately involved with my | Strongly agree | 26 | 35% |
| | Agree | 19 | 25% |

| Variables | Categories | Frequency | Percentage out of total |
|---|---|---|---|
| performance and studies at the institution. | Uncertain | 9 | 12% |
| | Disagree | 10 | 13% |
| | Strongly disagree | 11 | 15% |
| **47.** My department interacts and supports students through healthy interventions with evaluation performance. | Strongly agree | 10 | 13% |
| | Agree | 20 | 27% |
| | Uncertain | 19 | 25% |
| | Disagree | 12 | 16% |
| | Strongly disagree | 14 | 19% |
| **48.** There is a positive attitude within the industrial engineering teaching environment. | Strongly agree | 16 | 21% |
| | Agree | 27 | 36% |
| | Uncertain | 20 | 27% |
| | Disagree | 4 | 5% |
| | Strongly disagree | 8 | 11% |
| **49.** My industrial engineering department supports its instructors with the resources necessary to perform their duties. | Strongly agree | 10 | 13% |
| | Agree | 22 | 29% |
| | Uncertain | 28 | 37% |
| | Disagree | 9 | 12% |
| | Strongly disagree | 6 | 8% |
| **50.** I am aware of the quality assurance bodies that monitor my industrial engineering programme at my institution. | Strongly agree | 12 | 16% |
| | Agree | 20 | 27% |
| | Uncertain | 20 | 27% |
| | Disagree | 14 | 19% |
| | Strongly disagree | 9 | 12% |

| Variables | Categories | Frequency | Percentage out of total |
|---|---|---|---|
| **51.** My institution interacts with the Engineering Council of South Africa together with students to develop industrial engineering. | Strongly agree | 17 | 23% |
| | Agree | 24 | 32% |
| | Uncertain | 16 | 21% |
| | Disagree | 8 | 11% |
| | Strongly disagree | 10 | 13% |

## Descriptive statistics of responses from institutions (lecturers)

**NB: Percentage totals were rounded off.**

| Variables | Categories | Frequency | Percentage out of total |
|---|---|---|---|
| Institution (Lecturer) Questionnaire | | | |
| **CATEGORY I: INDUSTRIAL ENGINEERING IN INDUSTRY** | | | |
| **1.** Industrial engineering is a branch of engineering that I have mastered fully. | Strongly agree | 4 | 33% |
| | Agree | 5 | 42% |
| | Uncertain | 2 | 17% |
| | Disagree | 1 | 8% |
| | Strongly disagree | 0 | 0% |
| **2.** Information and Knowledge building is part and parcel of an industrial engineer. | Strongly agree | 6 | 50% |
| | Agree | 5 | 42% |
| | Uncertain | 1 | 8% |
| | Disagree | 0 | 0% |
| | Strongly disagree | 0 | 0% |
| **3.** I am knowledgeable with the history of industrial engineering in | Strongly agree | 3 | 25% |
| | Agree | 7 | 58% |
| | Uncertain | 2 | 17% |
| | Disagree | 0 | 0% |

| Variables | Categories | Frequency | Percentage out of total |
|---|---|---|---|
| South African industry. | Strongly disagree | 0 | 0% |
| **4.** Industrial engineering plays a key role in the manufacturing and service industry in South Africa. | Strongly agree | 8 | 67% |
| | Agree | 3 | 25% |
| | Uncertain | 0 | 0% |
| | Disagree | 1 | 8% |
| | Strongly disagree | 0 | 0% |
| **5.** The South African economy is influenced by the role played by industrial engineers in industry. | Strongly agree | 6 | 50% |
| | Agree | 4 | 33% |
| | Uncertain | 1 | 8% |
| | Disagree | 1 | 8% |
| | Strongly disagree | 0 | 0% |
| **6.** There is an adequate awareness of industrial engineering by the industry regionally and nationally. | Strongly agree | 1 | 8% |
| | Agree | 3 | 25% |
| | Uncertain | 3 | 25% |
| | Disagree | 4 | 33% |
| | Strongly disagree | 1 | 8% |
| **7.** I have links with an industrial engineer(s) in industry. | Strongly agree | 4 | 33% |
| | Agree | 7 | 58% |
| | Uncertain | 0 | 0% |
| | Disagree | 1 | 8% |
| | Strongly disagree | 0 | 0% |
| **8.** My institution is capable of skilling graduate industrial | Strongly agree | 6 | 50% |
| | Agree | 5 | 42% |
| | Uncertain | 1 | 8% |

| Variables | Categories | Frequency | Percentage out of total |
|---|---|---|---|
| engineers to become productive. | Disagree | 0 | 0% |
| | Strongly disagree | 0 | 0% |
| **9.** A Bachelors degree and above in industrial engineering is adequate for an industrial engineer to perform in Industry | Strongly agree | 4 | 33% |
| | Agree | 6 | 50% |
| | Uncertain | 1 | 8% |
| | Disagree | 1 | 8% |
| | Strongly disagree | 0 | 0% |
| **10.** I am currently pursuing or intend to pursue industrial engineering related projects and activities in industry. | Strongly agree | 1 | 8% |
| | Agree | 6 | 50% |
| | Uncertain | 3 | 25% |
| | Disagree | 2 | 17% |
| | Strongly disagree | 0 | 0% |
| **CATEGORY II: INDUSTRIAL ENGINEERING IN ACADEMIA** | | | |
| **11.** I chose to teach / support industrial engineering as a career move. | Strongly agree | 4 | 33% |
| | Agree | 7 | 58% |
| | Uncertain | 0 | 0% |
| | Disagree | 1 | 8% |
| | Strongly disagree | 0 | 0% |
| **12.** Industrial engineering is a generalized skill in engineering. | Strongly agree | 4 | 33% |
| | Agree | 6 | 50% |
| | Uncertain | 1 | 8% |
| | Disagree | 1 | 8% |
| | Strongly disagree | 0 | 0% |
| **13.** I am passionate about | Strongly agree | 5 | 42% |

| Variables | Categories | Frequency | Percentage out of total |
|---|---|---|---|
| teaching industrial engineering. | Agree | 6 | 50% |
| | Uncertain | 0 | 0% |
| | Disagree | 1 | 8% |
| | Strongly disagree | 0 | 0% |
| **14.** I have mastered industrial engineering to a level that I am comfortable teaching it as a skill subject. | Strongly agree | 5 | 42% |
| | Agree | 5 | 42% |
| | Uncertain | 0 | 0% |
| | Disagree | 2 | 17% |
| | Strongly disagree | 0 | 0% |
| **15.** My institution has the practical capacity to teach industrial engineering using labs, workshops, industry visits, and among others. | Strongly agree | 3 | 25% |
| | Agree | 5 | 42% |
| | Uncertain | 2 | 17% |
| | Disagree | 0 | 0% |
| | Strongly disagree | 2 | 17% |
| **16.** I decided on my current institution of teaching as my first choice to pursue my desired teaching career. | Strongly agree | 3 | 25% |
| | Agree | 4 | 33% |
| | Uncertain | 2 | 17% |
| | Disagree | 3 | 25% |
| | Strongly disagree | 0 | 0% |
| **17.** Industrial engineering qualification comes in various NQF levels that I fully understand e.g. National diploma, | Strongly agree | 6 | 50% |
| | Agree | 6 | 50% |
| | Uncertain | 0 | 0% |
| | Disagree | 0 | 0% |
| | Strongly | 0 | 0% |

| Variables | Categories | Frequency | Percentage out of total |
|---|---|---|---|
| B.Tech, B degree and among others. | disagree | | |
| **18.** I fully understand what the industrial engineering curriculum expects of my students and myself. | Strongly agree | 5 | 42% |
| | Agree | 7 | 58% |
| | Uncertain | 0 | 0% |
| | Disagree | 0 | 0% |
| | Strongly disagree | 0 | 0% |
| **19.** My institution is providing me with suitable resources and teaching aids to allow me to fully develop and / or teach the theory and practice of industrial engineering. | Strongly agree | 5 | 42% |
| | Agree | 4 | 33% |
| | Uncertain | 1 | 8% |
| | Disagree | 1 | 8% |
| | Strongly disagree | 1 | 8% |
| **20.** My institution / department make me believe that my career choice can make a difference in my life and the economy. | Strongly agree | 4 | 33% |
| | Agree | 5 | 42% |
| | Uncertain | 1 | 8% |
| | Disagree | 1 | 8% |
| | Strongly disagree | 1 | 8% |
| **21.** I have the full support I need from my teaching and learning community. | Strongly agree | 4 | 33% |
| | Agree | 5 | 42% |
| | Uncertain | 2 | 17% |
| | Disagree | 0 | 0% |
| | Strongly disagree | 1 | 8% |

| Variables | Categories | Frequency | Percentage out of total |
|---|---|---|---|
| **22.** I feel personally encouraged to teach industrial engineering. | Strongly agree | 3 | 25% |
| | Agree | 1 | 8% |
| | Uncertain | 3 | 25% |
| | Disagree | 3 | 25% |
| | Strongly disagree | 2 | 17% |
| **23.** My current remuneration level is adequate given the work I do. | Strongly agree | 2 | 17% |
| | Agree | 0 | 0% |
| | Uncertain | 2 | 17% |
| | Disagree | 4 | 33% |
| | Strongly disagree | 4 | 33% |
| **24.** I am currently or intending to pursue a further qualification related to industrial engineering. | Strongly agree | 2 | 17% |
| | Agree | 5 | 42% |
| | Uncertain | 2 | 17% |
| | Disagree | 0 | 0% |
| | Strongly disagree | 3 | 25% |
| **25.** I know and understand the South African Qualifications Framework. | Strongly agree | 2 | 17% |
| | Agree | 7 | 58% |
| | Uncertain | 3 | 25% |
| | Disagree | 0 | 0% |
| | Strongly disagree | 0 | 0% |
| **26.** I understand the various industrial engineering NQF level descriptors | Strongly agree | 3 | 25% |
| | Agree | 7 | 58% |
| | Uncertain | 1 | 8% |
| | Disagree | 1 | 8% |
| | Strongly | 0 | 0% |

| Variables | Categories | Frequency | Percentage out of total |
|---|---|---|---|
| | disagree | | |
| **27.** I revise the course study guide with my students at the beginning of every semester. | Strongly agree | 3 | 25% |
| | Agree | 7 | 58% |
| | Uncertain | 1 | 8% |
| | Disagree | 1 | 8% |
| | Strongly disagree | 0 | 0% |
| **28.** My course structure is kept up-to-date following changes in industry needs and other regulating body requirements e.g. ECSA. | Strongly agree | 4 | 33% |
| | Agree | 7 | 58% |
| | Uncertain | 0 | 0% |
| | Disagree | 1 | 8% |
| | Strongly disagree | 0 | 0% |
| **29.** *My institution offers me the full financial and academic support to develop myself through training and qualification development programmes. | Strongly agree | 4 | 33% |
| | Agree | 3 | 25% |
| | Uncertain | 2 | 17% |
| | Disagree | 2 | 17% |
| | Strongly disagree | 1 | 8% |
| **CATEGORY III: QUALITY IN INDUSTRIAL ENGINEERING** | | | |
| **30.** The definition of industrial engineering is quality in itself. | Strongly agree | 7 | 58% |
| | Agree | 5 | 42% |
| | Uncertain | 0 | 0% |
| | Disagree | 0 | 0% |
| | Strongly | 0 | 0% |

| Variables | Categories | Frequency | Percentage out of total |
| --- | --- | --- | --- |
| | disagree | | |
| **31.** Industrial engineering is an innovative, knowledge based and enterprise based thinking process. | Strongly agree | 8 | 67% |
| | Agree | 3 | 25% |
| | Uncertain | 0 | 0% |
| | Disagree | 1 | 8% |
| | Strongly disagree | 0 | 0% |
| **32.** The current teaching material in South Africa is relevant to the industrial engineering qualification in South Africa. | Strongly agree | 4 | 33% |
| | Agree | 6 | 50% |
| | Uncertain | 1 | 8% |
| | Disagree | 1 | 8% |
| | Strongly disagree | 0 | 0% |
| **33.** The South African Industry objectives e.g. improving productivity, and among others is in line with what is taught at my institution. | Strongly agree | 3 | 25% |
| | Agree | 5 | 42% |
| | Uncertain | 2 | 17% |
| | Disagree | 2 | 17% |
| | Strongly disagree | 0 | 0% |
| **34.** We have regular input (e.g. forums) from Industry regarding the impact industrial engineering has on industry performance. | Strongly agree | 2 | 17% |
| | Agree | 5 | 42% |
| | Uncertain | 3 | 25% |
| | Disagree | 2 | 17% |
| | Strongly disagree | 0 | 0% |
| **35.** The level of teaching is adequate to skill the current industrial | Strongly agree | 3 | 25% |
| | Agree | 7 | 58% |
| | Uncertain | 1 | 8% |

| Variables | Categories | Frequency | Percentage out of total |
| --- | --- | --- | --- |
| engineer. | Disagree | 0 | 0% |
| | Strongly disagree | 1 | 8% |
| **36.** The material I lecture my students on is well understood and adequately links with the skills necessary to work in Industry. | Strongly agree | 2 | 17% |
| | Agree | 7 | 58% |
| | Uncertain | 2 | 17% |
| | Disagree | 1 | 8% |
| | Strongly disagree | 0 | 0% |
| **37.** The application process to study industrial engineering at my institution is clear and easy to understand. | Strongly agree | 1 | 8% |
| | Agree | 7 | 58% |
| | Uncertain | 2 | 17% |
| | Disagree | 2 | 17% |
| | Strongly disagree | 0 | 0% |
| **38.** The registration procedure and requirements at institutions of higher learning is run smoothly and not stressful to students. | Strongly agree | 2 | 17% |
| | Agree | 4 | 33% |
| | Uncertain | 3 | 25% |
| | Disagree | 1 | 8% |
| | Strongly disagree | 2 | 17% |
| **39.** The learning and teaching environment has a healthy and conducive study atmosphere. | Strongly agree | 2 | 17% |
| | Agree | 6 | 50% |
| | Uncertain | 1 | 8% |
| | Disagree | 1 | 8% |
| | Strongly disagree | 2 | 17% |

| Variables | Categories | Frequency | Percentage out of total |
|---|---|---|---|
| **40.** Information on industrial engineering at the institutions' classes, lectures and the library is readily available to students and staff. | Strongly agree | 4 | 33% |
| | Agree | 4 | 33% |
| | Uncertain | 2 | 17% |
| | Disagree | 1 | 8% |
| | Strongly disagree | 1 | 8% |
| **41.** The evaluation process conducted for industrial engineering at the institution is fair and unbiased. | Strongly agree | 1 | 8% |
| | Agree | 7 | 58% |
| | Uncertain | 2 | 17% |
| | Disagree | 1 | 8% |
| | Strongly disagree | 1 | 8% |
| **42.** Students have free and easy access to my tutoring instructors and myself. | Strongly agree | 4 | 33% |
| | Agree | 6 | 50% |
| | Uncertain | 2 | 17% |
| | Disagree | 0 | 0% |
| | Strongly disagree | 0 | 0% |
| **43.** The institution offers other means of developing my studies through e.g. tutor, tutorials, projects, and among others. | Strongly agree | 5 | 42% |
| | Agree | 5 | 42% |
| | Uncertain | 2 | 17% |
| | Disagree | 0 | 0% |
| | Strongly disagree | 0 | 0% |
| **44.** I am able to interact with institutions and groups internally and externally to develop | Strongly agree | 1 | 8% |
| | Agree | 3 | 25% |
| | Uncertain | 6 | 50% |
| | Disagree | 2 | 17% |

| Variables | Categories | Frequency | Percentage out of total |
|---|---|---|---|
| my knowledge of industrial engineering e.g. discussion groups and build the students understanding of the subject. | Strongly disagree | 0 | 0% |
| **45.** My institution interacts with industry stakeholders to develop industrial engineering to meet current industry standards. | Strongly agree | 3 | 25% |
| | Agree | 6 | 50% |
| | Uncertain | 2 | 17% |
| | Disagree | 1 | 8% |
| | Strongly disagree | 0 | 0% |
| **46.** My institution organises research, student projects, and competitions among others funded by Industry to bring awareness to industrial engineering and the students studying the course. | Strongly agree | 1 | 8% |
| | Agree | 7 | 58% |
| | Uncertain | 3 | 25% |
| | Disagree | 0 | 0% |
| | Strongly disagree | 1 | 8% |
| **47.** The students' family is intimately involved with the lecturers to follow up on the students' performance and studies at the | Strongly agree | 2 | 17% |
| | Agree | 5 | 42% |
| | Uncertain | 2 | 17% |
| | Disagree | 0 | 0% |
| | Strongly disagree | 3 | 25% |

| Variables | Categories | Frequency | Percentage out of total |
|---|---|---|---|
| institution. | | | |
| **48.** My department interacts and supports students through healthy interventions with evaluation performance. | Strongly agree | 3 | 25% |
| | Agree | 5 | 42% |
| | Uncertain | 2 | 17% |
| | Disagree | 1 | 8% |
| | Strongly disagree | 1 | 8% |
| **49.** There is a positive attitude within the industrial engineering teaching environment. | Strongly agree | 4 | 33% |
| | Agree | 4 | 33% |
| | Uncertain | 2 | 17% |
| | Disagree | 1 | 8% |
| | Strongly disagree | 1 | 8% |
| **50.** My industrial engineering department supports its instructors with the resources necessary to perform their duties. | Strongly agree | 2 | 17% |
| | Agree | 4 | 33% |
| | Uncertain | 1 | 8% |
| | Disagree | 0 | 0% |
| | Strongly disagree | 2 | 17% |
| **51.** I am aware of the quality assurance bodies that monitor my industrial engineering programme at my institution. | Strongly agree | 4 | 33% |
| | Agree | 0 | 0% |
| | Uncertain | 1 | 8% |
| | Disagree | 0 | 0% |
| | Strongly disagree | 0 | 0% |
| **52.** My institution interacts with the Engineering Council of South Africa | Strongly agree | 2 | 17% |
| | Agree | 1 | 8% |
| | Uncertain | 0 | 0% |

| Variables | Categories | Frequency | Percentage out of total |
|---|---|---|---|
| together with students to develop industrial engineering. | Disagree | 1 | 8% |
| | Strongly disagree | 0 | 0% |

## Descriptive statistics of responses from industry

**NB: Percentage totals were rounded off.**

(Southern African Institute for Industrial Engineering (SAIIE) and Engineering Council of South Africa (ECSA)

| Variables | Categories | Frequency | Percentage out of total |
|---|---|---|---|
| Industry representative Questionnaire | | | |
| **CATEGORY I: INDUSTRIAL ENGINEERING IN INDUSTRY** | | | |
| **1.** Industrial engineering is a branch of engineering that I have mastered fully. | Strongly agree | 16 | 24% |
| | Agree | 29 | 43% |
| | Uncertain | 11 | 16% |
| | Disagree | 11 | 16% |
| | Strongly disagree | 0 | 0% |
| **2.** Information and Knowledge building is part and parcel of an industrial engineer. | Strongly agree | 33 | 49% |
| | Agree | 26 | 39% |
| | Uncertain | 6 | 9% |
| | Disagree | 2 | 3% |
| | Strongly disagree | 0 | 0% |
| **3.** I am knowledgeable with the History of South African industrial engineering. | Strongly agree | 9 | 13% |
| | Agree | 27 | 40% |
| | Uncertain | 19 | 28% |
| | Disagree | 10 | 15% |
| | Strongly | 2 | 3% |

| Variables | Categories | Frequency | Percentage out of total |
|---|---|---|---|
| | disagree | | |
| **4.** Industrial engineering plays a key role in the manufacturing and service industry in South Africa. | Strongly agree | 33 | 49% |
| | Agree | 28 | 42% |
| | Uncertain | 5 | 7% |
| | Disagree | 1 | 1% |
| | Strongly disagree | 0 | 0% |
| **5.** The South African economy is influenced by the role played by industrial engineers in industry. | Strongly agree | 18 | 27% |
| | Agree | 22 | 33% |
| | Uncertain | 19 | 28% |
| | Disagree | 5 | 7% |
| | Strongly disagree | 3 | 4% |
| **6.** There is an adequate awareness of industrial engineering by the Industry regionally and nationally. | Strongly agree | 4 | 6% |
| | Agree | 11 | 16% |
| | Uncertain | 13 | 19% |
| | Disagree | 33 | 49% |
| | Strongly disagree | 6 | 9% |
| **7.** I have links with an industrial engineer(s) in industry. | Strongly agree | 18 | 27% |
| | Agree | 34 | 51% |
| | Uncertain | 7 | 10% |
| | Disagree | 8 | 12% |
| | Strongly disagree | 0 | 0% |
| **8.** The institution is contributing to skilling graduate industrial engineers to become | Strongly agree | 6 | 9% |
| | Agree | 37 | 55% |
| | Uncertain | 15 | 22% |
| | Disagree | 9 | 13% |

| Variables | Categories | Frequency | Percentage out of total |
|---|---|---|---|
| productive. | Strongly disagree | 0 | 0% |
| **9.** A bachelors degree and above in industrial engineering is adequate for an industrial engineer to perform in industry | Strongly agree | 24 | 36% |
| | Agree | 31 | 46% |
| | Uncertain | 6 | 9% |
| | Disagree | 5 | 7% |
| | Strongly disagree | 1 | 1% |
| **10.** I am currently pursuing or intend to pursue industrial engineering related projects and activities in industry. | Strongly agree | 33 | 49% |
| | Agree | 30 | 45% |
| | Uncertain | 3 | 4% |
| | Disagree | 1 | 1% |
| | Strongly disagree | 0 | 0% |
| **CATEGORY II: INDUSTRIAL ENGINEERING IN ACADEMIA** | | | |
| **11.** I chose to pursue industrial engineering as a career move. | Strongly agree | 30 | 45% |
| | Agree | 31 | 46% |
| | Uncertain | 3 | 4% |
| | Disagree | 3 | 4% |
| | Strongly disagree | 0 | 0% |
| **12.** Industrial engineering is a generalized skill in engineering. | Strongly agree | 12 | 18% |
| | Agree | 30 | 45% |
| | Uncertain | 11 | 16% |
| | Disagree | 12 | 18% |
| | Strongly disagree | 2 | 3% |
| **13.** I am passionate about supporting the ideals in | Strongly agree | 36 | 54% |
| | Agree | 20 | 30% |

| Variables | Categories | Frequency | Percentage out of total |
|---|---|---|---|
| industrial engineering. | Uncertain | 9 | 13% |
| | Disagree | 2 | 3% |
| | Strongly disagree | 0 | 0% |
| **14.** I have mastered industrial engineering to a level that I am comfortable training it as a skill. | Strongly agree | 17 | 25% |
| | Agree | 20 | 30% |
| | Uncertain | 23 | 34% |
| | Disagree | 7 | 10% |
| | Strongly disagree | 0 | 0% |
| **15.** Do learning institutions have the practical capacity to teach industrial engineering using labs, workshops, industry visits, and among others. | Strongly agree | 10 | 15% |
| | Agree | 20 | 30% |
| | Uncertain | 23 | 34% |
| | Disagree | 12 | 18% |
| | Strongly disagree | 2 | 3% |
| **16.** I chose this career as my first choice. | Strongly agree | 32 | 48% |
| | Agree | 15 | 22% |
| | Uncertain | 7 | 10% |
| | Disagree | 13 | 19% |
| | Strongly disagree | 0 | 0% |
| **17.** Industrial engineering qualification comes in various NQF levels that I fully understand e.g. National diploma, B.Tech, B degree and | Strongly agree | 23 | 34% |
| | Agree | 26 | 39% |
| | Uncertain | 10 | 15% |
| | Disagree | 8 | 12% |
| | Strongly disagree | 0 | 0% |

| Variables | Categories | Frequency | Percentage out of total |
|---|---|---|---|
| among others. | | | |
| **18.** I fully understand what the industrial engineering curriculum expects of students in institutions of higher learning. | Strongly agree | 20 | 30% |
| | Agree | 32 | 48% |
| | Uncertain | 11 | 16% |
| | Disagree | 4 | 6% |
| | Strongly disagree | 0 | 0% |
| **19.** Are institutions equipped with suitable resources and teaching aids allowing institutions of higher learning to fully develop and / or teach the theory and practice of industrial engineering? | Strongly agree | 4 | 6% |
| | Agree | 29 | 43% |
| | Uncertain | 23 | 34% |
| | Disagree | 9 | 13% |
| | Strongly disagree | 2 | 3% |
| **20.** Are institutions of higher learning supportive of their staff members in their commitment to making a difference in their lives and / or the economy? | Strongly agree | 4 | 6% |
| | Agree | 29 | 43% |
| | Uncertain | 28 | 42% |
| | Disagree | 5 | 7% |
| | Strongly disagree | 1 | 1% |
| **21.** Is the teaching and learning community | Strongly agree | 4 | 6% |
| | Agree | 32 | 48% |

| Variables | Categories | Frequency | Percentage out of total |
|---|---|---|---|
| supportive in the development and growth of the industrial engineering programme? | Uncertain | 23 | 34% |
| | Disagree | 8 | 12% |
| | Strongly disagree | 0 | 0% |
| **22.** I feel personally encouraged to develop industrial engineering. | Strongly agree | 31 | 46% |
| | Agree | 29 | 43% |
| | Uncertain | 6 | 9% |
| | Disagree | 0 | 0% |
| | Strongly disagree | 1 | 1% |
| **23.** Do you believe industrial engineering is adequately supported financially in research and development within learning institutions and industry? | Strongly agree | 7 | 10% |
| | Agree | 13 | 19% |
| | Uncertain | 20 | 30% |
| | Disagree | 26 | 39% |
| | Strongly disagree | 1 | 1% |
| **24.** Do you believe there is growth for further studies in the industrial engineering field? | Strongly agree | 27 | 40% |
| | Agree | 31 | 46% |
| | Uncertain | 6 | 9% |
| | Disagree | 3 | 4% |
| | Strongly disagree | 0 | 0% |
| **25.** I know and understand the South African Qualifications | Strongly agree | 12 | 18% |
| | Agree | 27 | 40% |
| | Uncertain | 16 | 24% |
| | Disagree | 10 | 15% |

| Variables | Categories | Frequency | Percentage out of total |
|---|---|---|---|
| Framework. | Strongly disagree | 2 | 3% |
| **26.** I understand the various industrial engineering NQF level descriptors | Strongly agree | 10 | 15% |
| | Agree | 22 | 33% |
| | Uncertain | 24 | 36% |
| | Disagree | 8 | 12% |
| | Strongly disagree | 3 | 4% |
| **27.** Is the curriculum of the industrial engineering programme capable and / or able to meet industry skills requirements. | Strongly agree | 6 | 9% |
| | Agree | 36 | 54% |
| | Uncertain | 18 | 27% |
| | Disagree | 7 | 10% |
| | Strongly disagree | 0 | 0% |
| **28.** Are institutions of higher learning maintaining the course structure in line with industry requirements and other regulating body e.g. ECSA. | Strongly agree | 7 | 10% |
| | Agree | 28 | 42% |
| | Uncertain | 27 | 40% |
| | Disagree | 5 | 7% |
| | Strongly disagree | 0 | 0% |
| **29.** *Institutions of higher learning are encouraging self-development. | Strongly agree | 3 | 4% |
| | Agree | 33 | 49% |
| | Uncertain | 24 | 36% |
| | Disagree | 6 | 9% |
| | Strongly disagree | 1 | 1% |
| **CATEGORY III: QUALITY IN INDUSTRIAL ENGINEERING** | | | |

| Variables | Categories | Frequency | Percentage out of total |
|---|---|---|---|
| **30.** The definition of industrial engineering is quality in itself. | Strongly agree | 12 | 18% |
| | Agree | 24 | 36% |
| | Uncertain | 11 | 16% |
| | Disagree | 18 | 27% |
| | Strongly disagree | 2 | 3% |
| **31.** Industrial engineering is an innovative, knowledge based and enterprise based thinking process. | Strongly agree | 23 | 34% |
| | Agree | 41 | 61% |
| | Uncertain | 2 | 3% |
| | Disagree | 1 | 1% |
| | Strongly disagree | 0 | 0% |
| **32.** The current teaching material is relevant to the industrial engineering qualification in South Africa. | Strongly agree | 12 | 18% |
| | Agree | 41 | 61% |
| | Uncertain | 9 | 13% |
| | Disagree | 5 | 7% |
| | Strongly disagree | 0 | 0% |
| **33.** The South African Industry objectives e.g. improving productivity, and among others is in line with what is taught at institution of higher learning. | Strongly agree | 11 | 16% |
| | Agree | 43 | 64% |
| | Uncertain | 10 | 15% |
| | Disagree | 3 | 4% |
| | Strongly disagree | 0 | 0% |
| **34.** There is sufficient evidence from institutions of higher | Strongly agree | 5 | 7% |
| | Agree | 17 | 25% |
| | Uncertain | 30 | 45% |

| Variables | Categories | Frequency | Percentage out of total |
|---|---|---|---|
| learning on regular inputs (e.g. forums) from Industry regarding the impact industrial engineering has on industry performance. | Disagree | 15 | 22% |
| | Strongly disagree | 0 | 0% |
| **35.** The level of teaching is adequate to skill the current industrial engineer. | Strongly agree | 4 | 6% |
| | Agree | 34 | 51% |
| | Uncertain | 23 | 34% |
| | Disagree | 6 | 9% |
| | Strongly disagree | 0 | 0% |
| **36.** The materials aiding the lecturing of industrial engineering is well understood by learners, including teachers and adequately links with the skills necessary to work in Industry. | Strongly agree | 7 | 10% |
| | Agree | 33 | 49% |
| | Uncertain | 20 | 30% |
| | Disagree | 6 | 9% |
| | Strongly disagree | 1 | 1% |
| **37.** The application process to study industrial engineering at my institution is clear and easy to understand. | Strongly agree | 9 | 13% |
| | Agree | 39 | 58% |
| | Uncertain | 15 | 22% |
| | Disagree | 3 | 4% |
| | Strongly disagree | 1 | 1% |
| **38.** The registration procedure and | Strongly agree | 10 | 15% |
| | Agree | 26 | 39% |

| Variables | Categories | Frequency | Percentage out of total |
|---|---|---|---|
| requirements at institutions of higher learning is run smoothly and not stressful to students. | Uncertain | 23 | 34% |
| | Disagree | 7 | 10% |
| | Strongly disagree | 1 | 1% |
| **39.** The learning and teaching environment has a healthy and conducive study atmosphere. | Strongly agree | 8 | 12% |
| | Agree | 31 | 46% |
| | Uncertain | 23 | 34% |
| | Disagree | 5 | 7% |
| | Strongly disagree | 0 | 0% |
| **40.** Information on industrial engineering at institutions of higher learning is current and readily available. | Strongly agree | 7 | 10% |
| | Agree | 37 | 55% |
| | Uncertain | 19 | 28% |
| | Disagree | 4 | 6% |
| | Strongly disagree | 0 | 0% |
| **41.** The evaluation process conducted for industrial engineering at institutions of higher learning is fair and unbiased. | Strongly agree | 8 | 12% |
| | Agree | 38 | 57% |
| | Uncertain | 20 | 30% |
| | Disagree | 1 | 1% |
| | Strongly disagree | 0 | 0% |
| **42.** Students have free and easy access to tutoring instructors and lectures at institutions of higher learning. | Strongly agree | 7 | 10% |
| | Agree | 38 | 57% |
| | Uncertain | 21 | 31% |
| | Disagree | 1 | 1% |
| | Strongly | 0 | 0% |

| Variables | Categories | Frequency | Percentage out of total |
|---|---|---|---|
| | disagree | | |
| **43.** Institutions of Higher learning offer sufficient means of developing learners' studies through e.g. tutor, tutorials, projects, and among others. | Strongly agree | 5 | 7% |
| | Agree | 46 | 69% |
| | Uncertain | 14 | 21% |
| | Disagree | 2 | 3% |
| | Strongly disagree | 0 | 0% |
| **44.** I am able to interact with institutions and groups internally and externally to develop my knowledge of industrial engineering e.g. discussion groups and build the students understanding of the subject. | Strongly agree | 10 | 15% |
| | Agree | 34 | 51% |
| | Uncertain | 15 | 22% |
| | Disagree | 8 | 12% |
| | Strongly disagree | 0 | 0% |
| **45.** Southern African Institute for Industrial Engineers (SAIIE) interacts sufficiently with industry stakeholders to develop industrial engineering to meet current industry standards. | Strongly agree | 8 | 12% |
| | Agree | 29 | 43% |
| | Uncertain | 18 | 27% |
| | Disagree | 11 | 16% |
| | Strongly disagree | 1 | 1% |
| **46.** Southern African | Strongly agree | 6 | 9% |

| Variables | Categories | Frequency | Percentage out of total |
|---|---|---|---|
| Institute for Industrial Engineers (SAIIE) organises adequate research, student projects, competitions, and among others funded by Industry to bring awareness to industrial engineering and the students studying the course. | Agree | 23 | 34% |
| | Uncertain | 20 | 30% |
| | Disagree | 14 | 21% |
| | Strongly disagree | 4 | 6% |
| **47.** There is adequate participation and follow up of the students' academic progress by the students' guardian / sponsors at institutions of Higher learning. | Strongly agree | 2 | 3% |
| | Agree | 25 | 37% |
| | Uncertain | 33 | 49% |
| | Disagree | 6 | 9% |
| | Strongly disagree | 1 | 1% |
| **48.** Institutions of Higher learning effectively interact and support students through healthy interventions with evaluation performance. | Strongly agree | 6 | 9% |
| | Agree | 27 | 40% |
| | Uncertain | 25 | 37% |
| | Disagree | 9 | 13% |
| | Strongly disagree | 0 | 0% |
| **49.** There is a positive attitude within the industrial engineering | Strongly agree | 11 | 16% |
| | Agree | 36 | 54% |
| | Uncertain | 19 | 28% |

| Variables | Categories | Frequency | Percentage out of total |
|---|---|---|---|
| teaching environment. | Disagree | 0 | 0% |
| | Strongly disagree | 1 | 1% |
| **50.** Industrial engineering at institutions of higher learning supports its instructors with the resources necessary to perform their duties. | Strongly agree | 3 | 25% |
| | Agree | 6 | 50% |
| | Uncertain | 1 | 8% |
| | Disagree | 0 | 0% |
| | Strongly disagree | 2 | 17% |
| **51.** Institutions of higher learning participate actively and positively with quality assurance bodies that monitor the industrial engineering programme. | Strongly agree | 7 | 58% |
| | Agree | 0 | 0% |
| | Uncertain | 4 | 33% |
| | Disagree | 1 | 8% |
| | Strongly disagree | 0 | 0% |
| **52.** Southern African Institute for Industrial Engineers (SAIIE) interacts adequately to develop industrial engineering with students at institutions of higher learning. | Strongly agree | 7 | 58% |
| | Agree | 3 | 25% |
| | Uncertain | 0 | 0% |
| | Disagree | 2 | 17% |
| | Strongly disagree | 0 | 0% |

# ANNEXURE B

## Statistical data calculations from student sample group

Data representing industrial engineering in industry

| | | | |
|---|---|---|---|
| Cronbach's Alpha | 0.880438134 | Reliability Calculator | |
| Split-Half (odd-even) Correlation | 0.937406296 | **created by Del Siegle (dsiegle@uconn.edu)** | |
| Spearman-Brown Prophecy | 0.96769201 | | |
| Mean for Test | 2.026666667 | | |
| Standard Deviation for Test | 1.143281826 | | |
| KR21 | -0.26252954 | Statements | Subjects |
| KR20 | -0.26252954 | 10 | 5 |

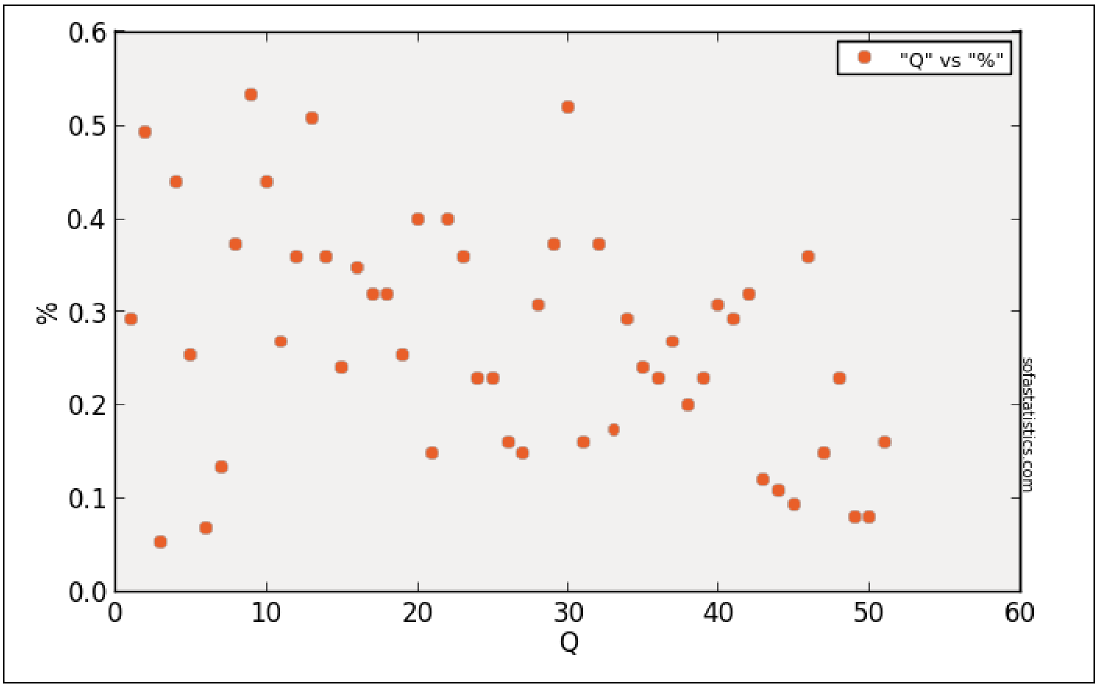
Data representing industrial engineering in academia

| | | | |
|---|---|---|---|
| Cronbach's Alpha | 0.944817454 | Reliability Calculator | |
| Split-Half (odd-even) Correlation | 0.999359104 | **created by Del Siegle (dsiegle@uconn.edu)** | |
| Spearman-Brown Prophecy | 0.999679449 | | |
| Mean for Test | 3.648 | | |
| Standard Deviation for Test | 1.677577089 | | |
| KR21 | -0.03551921 | Statements | Subjects |
| KR20 | -0.03551921 | 18 | 5 |

Data representing quality in industrial engineering

| | | | |
|---|---|---|---|
| Cronbach's Alpha | 0.963767596 | Reliability Calculator | |
| Split-Half (odd-even) Correlation | 0.931136199 | **created by Del Siegle (dsiegle@uconn.edu)** | |
| Spearman-Brown Prophecy | 0.964340267 | | |
| Mean for Test | 4.466666667 | | |
| Standard Deviation for Test | 2.009824757 | | |
| KR21 | 0.113922035 | Statements | Subjects |
| KR20 | 0.116769786 | 23 | 5 |

Results of the spearman’s test of linear correlation for statements vs. percentage out of total. ‘p’ value is 0.005, spearman's R statistic is -0.383 and degrees of Freedom (df) is 49



## Statistical data calculations from institution sample group

Data representing industrial engineering in industry

| | | | | |
|---|---|---|---|---|
| Cronbach's Alpha | 0.947504708 | Reliability Calculator | | |
| Split-Half (odd-even) Correlation | 0.967222458 | **created by Del Siegle (dsiegle@uconn.edu)** | | |
| Spearman-Brown Prophecy | 0.983338162 | | | |
| Mean for Test | 2 | | | |
| Standard Deviation for Test | 1.619327707 | | | |
| KR21 | 0.433145009 | Statements | Subjects | |
| KR20 | 0.433145009 | 10 | 5 | |

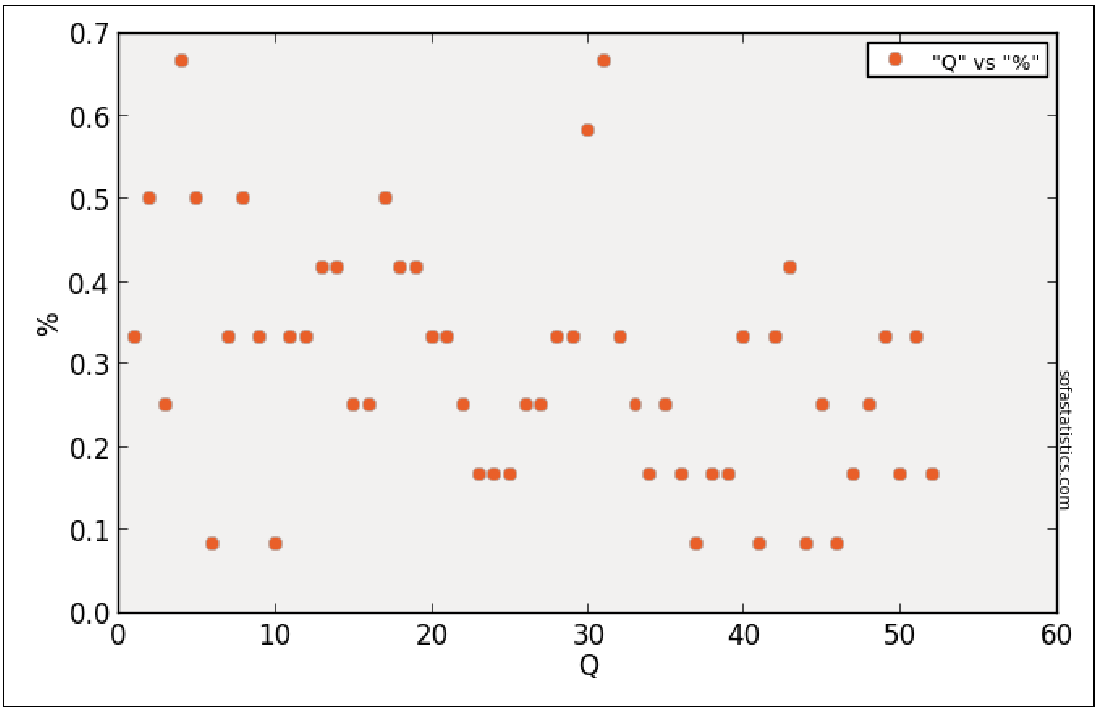
Data representing industrial engineering in academia

| | | | | |
|---|---|---|---|---|
| Cronbach's Alpha | 0.966821221 | Reliability Calculator | | |
| Split-Half (odd-even) Correlation | 0.99177151 | **created by Del Siegle (dsiegle@uconn.edu)** | | |
| Spearman-Brown Prophecy | 0.995868758 | | | |
| Mean for Test | 3.8 | | | |
| Standard Deviation for Test | 2.710883415 | | | |
| KR21 | 0.618906024 | Statements | Subjects | |
| KR20 | 0.618906024 | 19 | 5 | |

Data representing quality in industrial engineering

| | | | | |
|---|---|---|---|---|
| Cronbach's Alpha | 0.969060163 | Reliability Calculator | | |
| Split-Half (odd-even) Correlation | 0.981297021 | **created by Del Siegle (dsiegle@uconn.edu)** | | |
| Spearman-Brown Prophecy | 0.990560235 | | | |
| Mean for Test | 4.3 | | | |
| Standard Deviation for Test | 3.000277765 | | | |
| KR21 | 0.639418626 | Statements | Subjects | |
| KR20 | 0.642900024 | 23 | 5 | |

Results of the spearman's test of linear correlation for statements vs. percentage out of total. 'p' value is 0.006, spearman's R statistic is -0.376 and degrees of Freedom (df) is 50



## Statistical data calculations from industry sample group

Data representing industrial engineering in industry

| | |
|---|---|
| Cronbach's Alpha | 0.927748177 |
| Split-Half (odd-even) Correlation | 0.946485624 |
| Spearman-Brown Prophecy | 0.972507181 |
| Mean for Test | 2 |
| Standard Deviation for Test | 1.362483024 |
| KR21 | 0.153442455 |
| KR20 | 0.153442455 |

Reliability Calculator
**created by Del Siegle (dsiegle@uconn.edu)**

| Statements | Subjects |
|---|---|
| 10 | 5 |

Data representing industrial engineering in academia

| | |
|---|---|
| Cronbach's Alpha | 0.963060396 |
| Split-Half (odd-even) Correlation | 0.965335233 |
| Spearman-Brown Prophecy | 0.982361906 |
| Mean for Test | 3.8 |
| Standard Deviation for Test | 2.456130577 |
| KR21 | 0.523628873 |
| KR20 | 0.523628873 |

Reliability Calculator
**created by Del Siegle (dsiegle@uconn.edu)**

| Statements | Subjects |
|---|---|
| 19 | 5 |

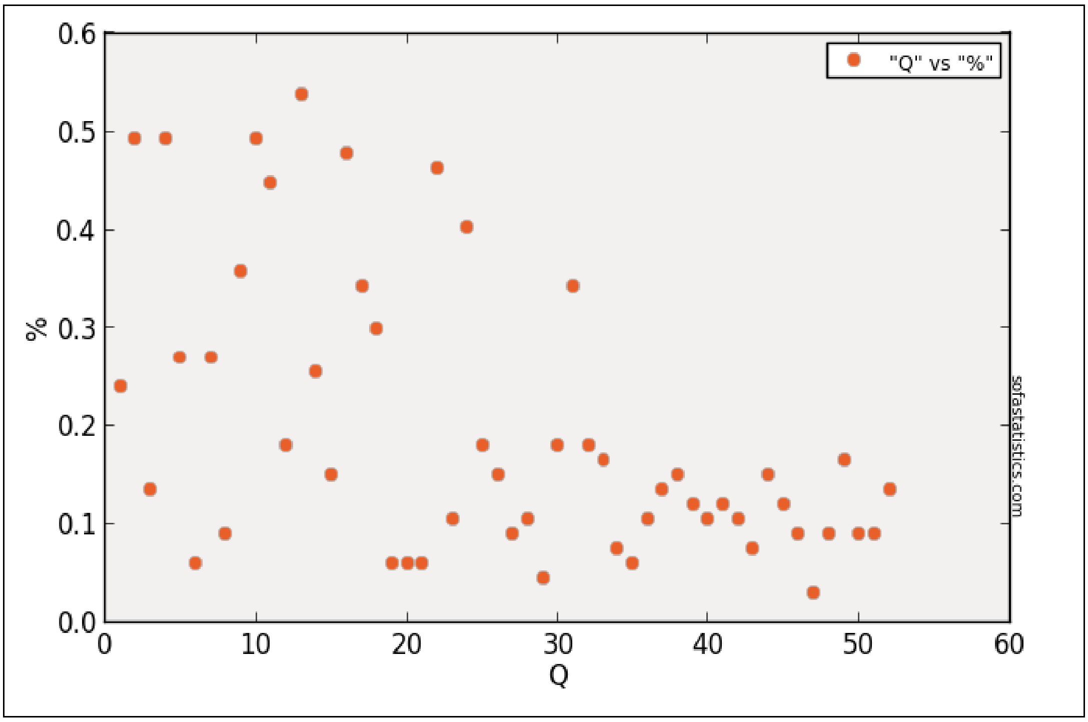
Data representing quality in industrial engineering

| | |
|---|---|
| Cronbach's Alpha | 0.989414645 |
| Split-Half (odd-even) Correlation | 0.980886668 |
| Spearman-Brown Prophecy | 0.990351123 |
| Mean for Test | 4.597014925 |
| Standard Deviation for Test | 3.843067665 |
| KR21 | 0.785087842 |
| KR20 | 0.785088445 |

Reliability Calculator
**created by Del Siegle (dsiegle@uconn.edu)**

| Statements | Subjects |
|---|---|
| 23 | 5 |

Results of the spearman's test of linear correlation for statements vs. percentage out of total. 'p' value is < 0.001.1, spearman's R statistic is -0.484 and degrees of Freedom (df) is 50



## ANNEXURE C

## Stellenbosch University (SUN) interview form:

Cape Peninsula University of Technology

Faculty of Engineering

Department of Industrial & Systems Engineering

Cape Peninsula University of Technology

P. O. Box 1906

Bellville

7535

**Consent Form**

**Re:** **A survey on Industry Expectations on Industrial Engineering Graduates:**

**A Case Study of Graduate Development Programmes in South African Universities.**

Dear Professor,

Cape Peninsula University of Technology (CPUT), Bellville Campus, is conducting a survey on the skills expectations placed on industrial engineering graduates, merging into the job market.

The study attempts to assess the value of industrial engineering within the South Africa market by looking at the quality aspect of industrial engineering and its modus operandi both at institutional and industry level.

I would like to request your permission to conduct this survey at your institution. We will respect the participant's right to privacy and protect the names and the identities of all participants and the organization during and after the process. All information is strictly confidential and for research purpose only.

Attached is an interview questionnaire, designed for the Head of departments / contact persons within the institutions discipline of Industrial Engineering. I would appreciate if you may read through and complete the required entries as you see fit.

**DECLARATION BY THE RESEARCHER**

I, hereby declare that to the best of my knowledge, I have fully explained the information written in this document and all aspect related to the research to:

(*Name of Participant*)________________________________________

Signed at: Cape Peninsula University of Technology (CPUT), Bellville on: 12 September 2012

**Signature of the researcher ______Ngetich WK______________________________**

***Further Information***

In the event there is a need to seek further information regarding this study, please feel free to contact the researcher:

Mr. Ngetich, W.K – Lecturer/researcher, Department of Industrial and Engineering Systems

Contact details: 021 953 8476 or 082 764 0541

**DECLARATION BY PARTICIPANT:**

**From:** ~~Mr. / Miss / Mrs. / Master~~: ______________________________

I declare that:

I understand the nature and requirements of the research undertaking as stated in your information letter, the copy of which I am in possession of; and pleased to consent to and grant approval for the research survey process and study to be perform in my organization.

I also consent that my information may be:

- Used and kept for future research studies [X]
- Used and discarded [ ]

Signed at: **3:30pm** on: **12 Sept. 2012** 2012

**Print Name**: ______________________________

**Signature of participant:** ______________________________

# PART I: EFFECTIVENESS

# What is Quality in Industrial Engineering?

## APPLICATION PROCESS (HOW RELEVANT IS THIS FIELD)

### KNOWLEDGE MANAGEMENT, INNOVATION MANAGEMENT & ENTERPRISE MANAGEMENT

1. Professor, what is the innovative management theory as far as Industrial Engineering is concerned and how is this relevant in the South African context?

   "Knowledge and Innovation management theory can be categorised into two basic areas, one is domain specific and the other is broad based without focusing on any particular discipline. Various factors drive Innovation theory, one of them being the need to arrive at a solution to a problem, and the other being that innovation theory is motivated by customer requirements and in some cases functional needs."

   "Innovation and knowledge theory is offered at the final year of the I.E. degree programme at Stellenbosch University. This subject equips the students with the necessary skill to deal with e.g. product or service strategy building based the philosophies surrounding innovation and knowledge management such as Charles Babbage theory of management."

   "Industrial engineering has been contributing to the South African market for about 30yrs focusing mainly on hard manufacturing and mechanical uses. Only recently has the industry shifted to using I.E. in the service industry such as the Logistics Management field, Supply Chain Management etc.... South Africa's industrial engineers are adequately capable of performing in various fields given their holistic systems perspective schooling."

2. What is the 'applicable relevant content'?

   "The relevant content taught at Stellenbosch is a thought process approach as opposed to the methods approach taught at most technological universities. The thought process approach allows for development of independent problem solving methodologies than focusing on specific focused techniques that are applicable to only specific fields."

3. Is the 'applicable relevant content' aligned with the current industry stakeholder objectives?

   "The stakeholder objectives being to equip students with knowledge that may add value to industry, then yes. There is a project that is driven by Stellenbosch called the 'Hope Project', which fosters for the creation of sustainable solutions to some of South Africa's and Africa's most pressing challenges. The Project embeds three core functions that highlight academic initiatives that serve human need (http://thehopeproject.co.za/hope/Pages/default.aspx)."

   1. "Teaching and learning,
   2. Research,
   3. Community interaction."

4. What are the resources and skills necessary to understand this theory?

   "Stellenbosch offers Industrial Engineering as a qualification from a Bachelors degree and higher. Potential engineering students sourced for this programme are done so against several measures, an important one being a strict provisional acceptance criteria and a high academic standard that demands a minimum of about 70% pass on core grade 12 subjects, i.e. Maths, English and Physical Sciences. Additionally, acceptance on a provisional basis depends on the students' capability to meet the monetary requirements expected of the full programme. These measures are important in ensuring the student's successful completion and consistency of studies, which is evident by the high throughput of over 80% that the department and Stellenbosch University is revered for."

5. What are the qualities applicable to an Industrial Engineer?

   "An Industrial Engineer should be 'productivity and efficiency' minded, analytical, systems minded, able to integrate physical and social sciences, sensitive and able to understand costing and economic factors and variables, and ability to manage effectively."

# PART II: EFFICIENCY

# Achieving Quality in Industrial Engineering

## ACADEMIC PROCESS (DELIVERY OF INDUSTRIAL ENGINEERING SKILL)

### KNOWLEDGE MANAGEMENT

1. How is this knowledge created?

   (Based on what teaching principles, curriculum approach, requirements?)

2. How is this knowledge developed or mined?

   (Research, publications, postgraduate studies?)

3. How is this knowledge compiled for relevance within the teaching curriculum for students to understand?

   (Methods of teaching / delivery)

### ACADEMIC MANAGEMENT

1. What is the Integrity of the academic process and how is it managed?

   (Quality control and assurance measures)

### QUALITY MANAGEMENT

1. How is the student application registration process managed?

   "As mentioned earlier the, potential engineering students sourced for this programme are done so against several measures, an important one being a strict provisional acceptance criteria and a high academic standard that demands a minimum of about 70% pass on core grade 12 subjects, i.e. Maths, English and Physical Sciences."

2. What approach is used in the delivery of this skill?

   (Teaching and learning process)

3. What Evaluation criteria is followed, and why?

   (Continuous evaluation, Exclusion policy)

4. Graduation process and passing criteria?

# Cape Peninsula University of Technology (CPUT) interview form:

Cape Peninsula University of Technology

Faculty of Engineering

Department of Industrial & Systems Engineering

Cape Peninsula University of Technology

P. O. Box 1906

Bellville

7535

## Consent Form

**Re:** **A survey on Industry Expectations on Industrial Engineering Graduates:**

**A Case Study of Graduate Development Programmes in South African Universities.**

Dear Participant,

Cape Peninsula University of Technology (CPUT), Bellville Campus, is conducting a survey on the skills expectations placed on industrial engineering graduates, merging into the job market.

The study attempts to assess the value of industrial engineering within the South Africa market by looking at the quality aspect of industrial engineering and its modus operandi both at institutional and industry level.

I would like to request your permission to conduct this survey at your institution. We will respect the participant's right to privacy and protect the names and the identities of all participants and the organization during and after the process. All information is strictly confidential and for research purpose only.

Attached is an interview questionnaire, designed for the Head of departments / contact persons within the institutions discipline of Industrial Engineering. I would appreciate if you may read through and complete the required entries as you see fit.

**DECLARATION BY THE RESEARCHER**

I, hereby declare that to the best of my knowledge, I have fully explained the information written in this document and all aspect related to the research to:

*(Name of Participant)* ***Mr Bharet Morar***

Signed at: Cape Peninsula University of Technology (CPUT), Bellville on: **17 Sept. 2012** 2012

**Signature of the researcher** ***Mr Ngetich WK***

***Further Information***

In the event there is a need to seek further information regarding this study, please feel free to contact the researcher:

Mr. Ngetich, W.K – Lecturer/researcher, Department of Industrial and Engineering Systems

Contact details: 021 953 8476 or 082 764 0541

**DECLARATION BY PARTICIPANT:**

**From:** Mr. ~~/ Miss / Mrs. / Master~~: ***Mr Bharet Morar***

I declare that:

I understand the nature and requirements of the research undertaking as stated in your information letter, the copy of which I am in possession of; and pleased to consent to and grant approval for the research survey process and study to be perform in my organization.

I also consent that my information may be:

- Used and kept for future research studies [X]
- Used and discarded [ ]

Signed at: **1 pm** on: **17 Sept. 2012** 2012

**Print Name**: ***Mr Bharet Morar***

**Signature of participant:** ***Mr Bharet Morar***

# PART I: EFFECTIVENESS

# What is Quality in Industrial Engineering?

## APPLICATION PROCESS (HOW RELEVANT IS THIS FIELD)

### KNOWLEDGE MANAGEMENT, INNOVATION MANAGEMENT & ENTERPRISE MANAGEMENT

1. What is the innovative management theory as far as Industrial Engineering is concerned and how is this relevant in the South African context?

   "There is a lag in the advancement of I.E. in South Africa. We need to involve industry as much as possible; industry is reluctant to participate with academic institutions. There is too much interference from politics in Academic operations and student affairs, political parties should steer away from influencing students into political activities within academia. The current industrial engineering research in South African is not as applicable in our current economic industries. There is a problem with the level of information and knowledge uptake with current students. The challenges include a notion students believe that BEE is the answer to equality and jobs, students inadequately prepared for both higher education and industry job performance, startling poor academic standards, Poor level of innovation depicted in current students of higher education."

2. What is the 'applicable relevant content'?

   "Productivity improvements, Service industry related skills."

3. Is the 'applicable relevant content' aligned with the current industry stakeholder objectives?

   "The progress between industry and academia is too slow to bring about immediate changes. There is a need for increased practice on industry related skills taught to students in higher education institutions."

4. What are the resources and skills necessary to understand this theory?

   "We need to enforce productive minimum entry-level requirements in high education institutions. Focus on language proficiency standards and requirements. Encourage analytical thinking, industrious attitudes, problem solving and continuous improvement notions and mindsets."

5. What are the qualities applicable to an Industrial Engineer?

   "Must be entrepreneurial."

# PART II: EFFICIENCY

# Achieving Quality in Industrial Engineering

## ACADEMIC PROCESS (DELIVERY OF INDUSTRIAL ENGINEERING SKILL)

### KNOWLEDGE MANAGEMENT

1. How is this knowledge created? (Based on what teaching principles, curriculum approach, requirements?)

   "Students and lecturing staff involved in more project and practical research activities. Through both industry and academic sourcing."

2. How is this knowledge developed or mined? (Research, publications, postgraduate studies?)

   "Through students and research, both working together."

3. How is this knowledge compiled for relevance within the teaching curriculum for students to understand? (Methods of teaching / delivery).

   "Through the use of Blooms Taxonomy."

### ACADEMIC MANAGEMENT

1. What is the Integrity of the academic process and how is it managed? (Quality control and assurance measures).

   "Management of knowledge is community based, developed individually through student and teacher relationship."

### QUALITY MANAGEMENT

1. How is the student application registration process managed?

"Very poorly, there is a need for more effective and efficient management of the process. The sourcing of students is not well processed as most students are ill equipped to deal with the level of knowledge, this heavily impacts on the institutions image in the society, industry and other institutions. Students are not academically proactive. Historically, the schooling background is not supportive of current universities."

2. What approach is used in the delivery of this skill? (Teaching and learning process)

   "Continuous assessment, currently only applied at CPUT."

3. What Evaluation criteria is followed, and why? (Continuous evaluation, Exclusion policy)

   "Not Answered."

4. Graduation process and passing criteria?

   "Poorly managed institutional policy on this issue. There is a need for better management."

# University of Johannesburg (UJ) interview form:

**Interview session with Mr Muyengwa**
**Location: University of Johannesburg, 17 Sept. 2012 @ _______ to ____**

**DECLARATION BY THE RESEARCHER**

I, hereby declare that to the best of my knowledge, I have fully explained the information written in this document and all aspect related to the research to:

(*Name of Participant)* *Goodwell Muyengwa* ________________________________________

Signed at:University of Johannesburg on 01 October ________________2012

**Signature of the researcher** ________________________________________

***Further Information***

In the event there is a need to seek further information regarding this study, please feel free to contact the researcher:

Mr. Ngetich, W.K – Lecturer/researcher, Department of Industrial and Engineering Systems

Contact details: 021 953 8476 or 082 764 0541

Page | 1

**DECLARATION BY PARTICIPANT:**

**From:** Mr. GOODWELL MUYENGWA

I declare that:

I understand the nature and requirements of the research undertaking as stated in your information letter, the copy of which I am in possession of; and pleased to consent to and grant approval for the research survey process and study to be perform in my organization.

I also consent that my information may be:

- Used and kept for future research studies [x]
- Used and discarded [ ]

Signed at: University of Johannesburg on: 01 October 2012

**Print Name**: Goodwell Muyengwa

**Signature of participant:** ____________

# PART I: EFFECTIVENESS

# What is Quality in Industrial Engineering?

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## APPLICATION PROCESS (HOW RELEVANT IS THIS FIELD)

### KNOWLEDGE MANAGEMENT, INNOVATION MANAGEMENT & ENTERPRISE MANAGEMENT

1. Mr Muyengwa, what is the innovative management theory as far as Industrial Engineering is concerned and how is this relevant in the South African context?

   The innovative management theory is taught in context. It involves teaching students to come up with new ideas on processes. This is done through subjects like Automation, Operational Research, Systems Dynamics and Quality Management.

   To the South African context it is important in improving processes and quality in our industry.

2. What is the 'applicable relevant content'?

   It involves increasing efficiency, productivity, profitability and safety.

3. Is the 'applicable relevant content' aligned with the current industry stakeholder objectives?

   Yes, because industry wants to cut costs and improve outputs.

4. What are the resources and skills necessary to understand this theory?

   Mathematics, Programming and understanding business skills like costing and accounting.

5. What are the qualities applicable to an Industrial Engineer?

Love working with people and must have a bigger picture of the company.

Have interest in how people and machines interact.

Must be proactive, inquisitive and analytical.

# PART II: EFFICIENCY

# Achieving Quality in Industrial Engineering

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## ACADEMIC PROCESS (DELIVERY OF INDUSTRIAL ENGINEERING SKILL)

### KNOWLEDGE MANAGEMENT

1. How is this knowledge created?

   (Based on what teaching principles, curriculum approach, requirements?)

2. How is this knowledge developed or mined?
   From Research and publications.

   (Research, publications, postgraduate studies?)

3. How is this knowledge compiled for relevance within the teaching curriculum for students to understand?

   (Methods of teaching / delivery)

Face to face teaching, giving students some handouts, case studies, labs and discussions.

### ACADEMIC MANAGEMENT

1. What is the Integrity of the academic process and how is it managed?

   (Quality control and assurance measures)

Students are assessed through assignments, tests and examinations. Internal quality control is done through moderation of tests within the Department. Examinations for exit levels subjects are moderated by external personnel. The Engineering Council of South Africa (ECSA) also audits our programme.

### QUALITY MANAGEMENT

1. How is the student application registration process managed?

   The University encourages On-line applications.

2. What approach is used in the delivery of this skill?

   (Teaching and learning process)

Learning objectives are made clear in the Study Guide issued to the student. Instructional activities are professionally done with proper preparation of the course material. Face to face teaching is conducted and students are afforded consultations to assist in the comprehension of the material being taught. The Department appoints tutors for challenging subjects.

3. What Evaluation criteria is followed, and why?

   (Continuous evaluation, Exclusion policy)

Students are evaluated through tests and examinations. Students are expected to pass at least 60 % of their courses during a semester. If a student fails to achieve 60 % he/she will get a warning. The warning stipulates that the student must pass all his/her subjects in the following semester. Students who fail badly or fail a repeating course will be excluded from the university. However students can appeal the exclusion decision.

4. Graduation process and passing criteria?

   To graduate a student must have passed 26 Academic courses and must have completed practical training, known as Experantuial training P1 and P2.

# ANNEXURE D

## Survey participants letter of invitation

Cape Peninsula
University of Technology

***FACULTY OF ENGINEERING***
*(Bellville Campus)*
*Mr. Ngetich W.K.*
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*Department: Industrial and Systems Engineering*

**RE: SURVEY ON INDUSTRY EXPECTATIONS ON INDUSTRIAL ENGINEERING GRADUATES**

Dear Participant,

The Faculty of Engineering and the Department of Industrial and Systems Engineering at the Cape Town, Bellville Campus at Cape Peninsula University of Technology (CPUT), is conducting a series of surveys as part of research on the skills expectations placed on Industrial Engineering graduates, merging into the job market.

The survey will take the form of carefully structured e-Surveys questions focusing on the following population sub groups:

1. Quality Assurance and Industry bodies:
2. Institutional bodies:
3. Students bodies:

The e-Surveys listed according to their respective subgroups & web links, are hosted by www.inqwise.com.

Please take a moment to complete the brief survey. Your participation is highly appreciated.

Thank you.

**LINKS TO SURVEY: Please click on the links below to participate on the survey**

1. *IEEA: Quality Assurance / Industry body*

**2012 SURVEY: INDUSTRIAL ENGINEERING; PERSPECTIVE FROM SOUTHERN AFRICAN INSTITUTE FOR INDUSTRIAL ENGINEERING (SAIIE) COUNCIL**

- http://c7.inqwise.com/c/1/85313ca1-db91-4548-be5e-894aca68b8b5/1

2. *ECSA: Quality Assurance / Industry body*

**2012 SURVEY: INDUSTRIAL ENGINEERING; PERSPECTIVE FROM THE ENGINEERING COUNCIL OF SOUTH AFRICA (ECSA)**

- http://c7.inqwise.com/c/1/295e6364-5d37-4818-b561-2bf4d9bac6d7/1

3. *STUDENTS: Student body*

**INDUSTRIAL ENGINEERING STUDENT SURVEY**

- http://c7.inqwise.com/c/1/de38c073-8453-4cd7-b391-f3013436c335/1

4. *LECTURES: Institutional body*

**LECTURER / INSTITUTION QUESTIONNAIRE 2012 SURVEY**

- http://c7.inqwise.com/c/1/b5c8ded3-3606-499b-ad5e-fa0123b37c98/1

*Acknowledgement and appreciation to www.inqwise for hosting the these series of e-Surveys*