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Trends preventing engineers from obtaining professional registration with ECSA in the required time

A Minor Dissertation Submitted in Partial Fulfilment of the Degree of

MAGISTER PHILOSOPHAE

in

ENGINEERING MANAGEMENT

at the

FACULTY OF ENGINEERING AND THE BUILT ENVIRONMENT

of the

UNIVERSITY OF JOHANNESBURG

by

Mr. NISHAAL ROOPLALL

21 August 2016

SUPERVISOR: Dr. Annlizé Marnewick
DECLARATION

I, Nishaal Rooplall, hereby declare that this minor dissertation has been submitted by myself to the University of Johannesburg, for the degree of Magister Philosophae in Engineering Management.

I also hereby declare that the work presented in this minor dissertation is completely my own work and that I have not submitted it for a degree at any other educational institution.

Nishaal Rooplall
ABSTRACT

The development of graduate engineers has become increasingly important in the engineering industry. Effectively developing engineering skills in graduate engineers, can assist them obtain professional registration with ECSA in the required time.

Graduate engineers are expected to obtain professional registration with ECSA within a time-frame of approximately 3 years, however this is not always achieved in the South African engineering industry. It is vital that engineers are able to operate at the expected levels of a professional engineer in the required time. This could promote the growth of the engineering sector as a whole in South Africa, as ECSA registered professional engineers are internationally recognized.

The research focuses on previous literature and industry research through the use of an online survey, which targeted engineers currently working in the South African industry. The survey investigated the trends in the workplace of candidate engineers, professional engineers as well as engineers not registered with ECSA. Investigations prove that ECSA registered candidate engineers were not always working at the correct levels of responsibility in the workplace and were not obtaining professional registration with ECSA in the suggested time-frame. The research showed similar results for professional engineers registered with ECSA and for engineers who are not registered with ECSA.

This research presents the findings of the research conducted and discusses the identified self-development and training needs of engineers in South Africa. Upon investigation into the trends of South African candidate engineers, professional engineers and engineers not registered with ECSA, it was established that engineers do not achieve professional registration within the required time. They furthermore do not always operate at the expected levels of responsibility in the workplace as suggested by literature.

The research also presents the methods which were researched in facilitating the development of skills in engineers.
ACKNOWLEDGEMENTS

Thank you to my Gods and Goddesses for the spiritual blessing, support and guidance continuously provided to me.

To my family and to the many friends who have supported me on this journey. Thank you. Without your patience and support I would have never completed this research.

I would also like to express my deepest gratitude to my supervisor, Dr. Annlizé Marnewick, for the support and guidance she has shown to me throughout this research project.

Thanks to all colleagues who took the time to participate in the survey. Without their input, this research would have not been possible.

Finally, thank you to my parents, for providing my sister and I with a solid foundation of good values and beliefs to build our lives on. It is thanks to the three of you that I was able to believe in myself and complete this research.
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# ABBREVIATIONS

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<th>Full Form</th>
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<tbody>
<tr>
<td>ASCE</td>
<td>American Society of Civil Engineers</td>
</tr>
<tr>
<td>B.Eng.</td>
<td>Bachelor of Engineering</td>
</tr>
<tr>
<td>B.Sc.</td>
<td>Bachelor of Science</td>
</tr>
<tr>
<td>B.Tech.</td>
<td>Bachelor of Technology</td>
</tr>
<tr>
<td>CESA</td>
<td>Consulting Engineers South Africa</td>
</tr>
<tr>
<td>CETA</td>
<td>Construction Education and Training Authority</td>
</tr>
<tr>
<td>ECSA</td>
<td>Engineering Council of South Africa</td>
</tr>
<tr>
<td>EPA</td>
<td>Engineering Profession Act</td>
</tr>
<tr>
<td>IEA</td>
<td>International Engineering Alliance</td>
</tr>
<tr>
<td>JPL</td>
<td>Jet Propulsion Laboratory</td>
</tr>
<tr>
<td>KPI</td>
<td>Key Performance Indicator</td>
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<tr>
<td>NASA</td>
<td>National Aeronautics and Space Administration</td>
</tr>
<tr>
<td>SABATCO</td>
<td>South African Black Technical &amp; Allied Careers Organisation</td>
</tr>
<tr>
<td>SAIEE</td>
<td>South African Institute of Electrical Engineers</td>
</tr>
<tr>
<td>SAICE</td>
<td>South African Institution of Civil Engineering</td>
</tr>
<tr>
<td>SAIMM</td>
<td>South African Institute of Mining and Metallurgy</td>
</tr>
</tbody>
</table>
1. **CHAPTER 1: Introduction and Overview**

1.1. **Introduction**

The industry of engineering has existed for a number of years, however it has only recently been identified that many graduate engineers lack generic/soft skills [1]. Opinions about required engineering skills vary throughout different industries, whereby it is believed that some people are born with certain attributes, and others believe that these attributes can be taught to the average person [1].

Engineering professionals are often required to have strong personalities with exceptional people skills in order to deliver projects within budget and on time. In the modern engineering industry, it is fast becoming a requirement for these professionals to demonstrate quality engineering skills [1].

1.2. **Overview**

It is often said that engineers are hired for their technical skills, promoted for their management skills and fired for their lack of people skills [2]. Graduate engineers are often required to display exceptional engineering skills in order to deliver engineering projects successfully in the modern world [3]. Although the discipline of engineering has existed for a number of years, only a fraction of projects are successfully completed [3]. This displays a need to explore the factors which affect engineering project success. A vital factor responsible for the success of engineering projects is the quality of skills [3]. In the modern world of engineering, it has been found that graduate engineers are only sometimes able to instantaneously display attributes of technical engineering skills with no additional training [1]. Educational institutions across the world have identified the need to slowly introduce engineering students to the skills required in the working environment [1].

In order to meet the needs of the 21st century engineering industry, it is important that graduate engineers are equipped with skills such as leadership, business acumen, strategic foresight and engineering knowledge [4]. High levels of professional skills in engineering have shown improvements in managing relationships across organisations. This improves an engineer’s ability to develop stronger relationships with people, which ultimately aids in delivering successful projects [5].

Developing skills, especially in graduate engineers is fast becoming an important aspect of universities and organisations, through graduate engineering programs [6]. The high-level role which engineers fill in engineering projects requires the said individual to exhibit important skills such as leadership, dedication, commitment, passion and most importantly, sound technical engineering knowledge, amongst many other skills [6].

1.3. **Problem Statement**

Engineering graduates who enter the labour market may find that part of their job description requires them to have certain personal traits and abilities [1].
Researchers such as Schoephoerster and Golding [4], Porter [7], Ozgen, et al [8] and Ellis and Peterson [9] discovered that some of the reasons as to why graduate engineers do not develop into good engineering professionals are due to the following:

- Insufficient training during a graduate engineer’s studies at university level [4][8][9].
- Having the incorrect supervisors and managers once they are in the working environment [7].
- A lack of personal self-leadership morals, ethics and values present in graduate engineer’s [4].
- Not being given the correct platforms to harness their natural strengths and develop their weaknesses in order to enhance their skills [7].

Effective engineering skills have proven to be one of the critical factors which contribute to project success and failure [10]. Engineers who have sound professional abilities can be differentiated from the average engineer and this has been seen in the management and operating of their projects and organisations [3]. It is believed that graduate engineers who may lack these abilities can be developed into efficient engineering professionals through a combination of suitable education and sufficient mentorship in the workplace [3].

The South African labour force suffers from deficiencies of engineering knowledge and ability in actual working requirements. It should not be assumed that universities will realize these deficiencies and incorporate them into current curriculum to bridge this gap [11]. They have established that the shortage of professional engineering capacity in South Africa is one of the worst scarce skills crises in years [11]. Graduate engineers are growing increasingly frustrated by the lack of opportunities, to learn and to grow into professionally recognized engineers through experience [12].

The Engineering Council of South Africa (ECSA), states that South Africa has approximately half of the engineers it needs in order to meet its development potential [13]. This is due to the fact that many engineers find other work with higher salaries [13]. It was established that a large number of graduate engineers were lacking the basic supervision and mentorship they require from older professionals in order to help develop themselves into professional engineers [12]. Following graduation, engineering students lack the experience and maturity needed to achieve actual professional competencies [14]. It is expected that through their education they would have developed competencies which can prepare them for the professional industry [14].

There are two types of gaps between graduate qualifications and job requirements. Graduate qualifications can exceed job requirements which creates a mismatch of over education, and job requirements can exceed graduate qualifications which creates a mismatch of under qualification [11]. This means that overqualified graduates can successfully fill job requirements whilst under qualified graduates will find it challenging to cope without effective mentorship and training in the workplace [11].

The problem this research will focus on is as follows:
Problem Statement:

Graduate engineers are expected to operate as professional engineers within a time-frame of approximately 3 years after graduation; however the opportunity to develop themselves into professional engineers within this time-frame is not currently achieved in the working environment.

1.4. Research Objectives

The main objective of the research is to determine the current professional registration trends of engineers in South Africa for graduate engineers to use as assistance in obtaining professional registration with ECSA.

The research will assist graduate engineers in measuring the development of their skills in the workplace. This will assist them in determining the skills they are required to develop in the workplace over a required period of time in order to register as professional engineers with ECSA.

The research objectives were directed to answer the problem statement above. The research will:

- Aim to uncover the skills to be developed in graduate engineers from the time of entering the labour market as a graduate engineer, to being able to register as a professional engineer.
- Aim to investigate the professional registration trends, with ECSA of engineers in the South African engineering industry. These trends would establish the initial registration trends of engineers as well as provide an insight into the levels of responsibility which engineers operate at during their registration process. Ensuring that engineers operate at the suggested levels of responsibility could further assist them in obtaining professional registration within the required time.

These trends will be able to analyse the current time taken for engineers to obtain professional registration with ECSA and to determine the levels of responsibility which engineers operate at in the workplace.

1.5. Research Questions

In order to achieve the research aim, the following research questions will be investigated:

Research Question 1 – What levels of responsibility are engineers expected to operate at in the workplace, from the time of graduating to the time of registering as a professional engineer?

Research Question 2 - What levels of responsibility do engineers actually operate at in the workplace, from the time of graduating to the time of registering as a professional engineer?

Research Question 3 – How can the development of engineering skills be facilitated in the working environment to ensure that engineers operate at the appropriate levels of responsibility in order to achieve professional engineering status?
The following research process will be followed in order to investigate solutions to this research problem. Research will be done by investigating the attributes gained by graduate engineers and the trends of engineers in South Africa. Previous literature will be referenced to derive the skills which graduate engineers and professional engineers are expected to possess. Methods on developing the skills of graduate engineers will also be researched. Detailed analysis will be done to determine if there is a development process between these two phases of an engineer’s career. Conclusions and summaries will then be completed from the collected data.

1.6. **Research Process**

![Figure 1 – Research process](15)

Figure 1 above represents a flow chart for the research process carried out. A research proposal was drawn up and submitted to the University of Johannesburg for approval prior to any work being carried out. Once the research proposal was approved, the research objectives and the research questions were set. These explained the purpose of the research and what type of research will be done in order to find possible solutions to the proposed research problem.
The literature review includes descriptions and interpretations of previous research investigated regarding this problem. Following the studying of previous research, data will be collected from engineers in the current industry. The next phase of the research process includes analysing the industry data collected. This is followed by developing conclusions and recommendations to the research problem.

1.7. **Research Report Layout**

Chapter 1 provides an insight and basic overview into the research. Descriptions of how the research process will be conducted, definitions of the problem statement and the research questions are defined. An introduction to the research is provided.

Chapter 2 focuses on providing an understanding of the literature reviewed for the research. The literature review provided data which other researchers had previously found in the scope of development of graduate engineers. It also provided potential solutions to these past problems, and a platform to work on, in developing solutions to the research questions.

Chapter 3 gives an explanation of the research methodology selected to carry out the actual industry research. Methods on the choice of research method and details on effectively carrying out the appropriate type of research method are discussed.

Chapter 4 discusses the results of the actual industry research and provides a detailed analysis on these results. These results will assist in determining answers to the problem statement and to the research questions stated in Chapter 1.

Chapter 5 provides the conclusions to the research conducted.

1.8. **Conclusions**

In the growing industry of engineering, the development of graduate engineers has become increasingly important, as young people are believed to be the future of the world. Developing sound effective skills in graduate engineers could create a different trend in the traditional growth of an engineer. This may hold the key to producing bright, young engineers who are able to make a difference to the world we live in.

It had been identified that graduate engineers often encounter development challenges when entering the working environment. A problem statement had been established which stated that graduate engineers are not being provided with the required training and mentorship in the workplace, in order to register as professional engineers in the required time. The research questions asked were aimed at understanding what existing and current knowledge there is on the research problem and to discover possible solutions to this problem.
The aim of this research is to provide the current professional registration trends of engineers in South Africa. This will assist graduate engineers in being able to professionally develop their skills from the time of entering the labour market as a graduate engineer to being able to successfully register as a professional engineer.

Chapter 2 below focuses on providing an understanding of the literature reviewed for the research. The literature review provided data which other researchers had previously found in the scope of development of graduate engineers. It also provided potential solutions to these past problems, and a platform to work on, in developing solutions to the research questions.
2. **CHAPTER 2: Literature Review**

2.1. **Introduction**

This chapter explores the options available to graduate engineers in obtaining the relevant knowledge and experience required to register as a professional engineer. It will identify the skills which graduate engineers and professional engineers should possess as well as methods to develop graduate engineers.

The literature researched can be sub-divided into the following categories which are described in detail in this chapter.

- Engineering education outcomes as per university and the professional regulatory body's standards.
- Literature from engineering organisations, universities, and professional bodies in developing graduate engineers into professional engineers.

2.2. **Engineering Education Outcomes**

2.2.1. **Outcomes Expected from Graduate Engineers**

The first stage in the development of an engineer is the acquisition of an accredited educational engineering qualification [16]. An engineering education is a developmental journey which students take in order to prepare themselves for a professional engineering career [17]. Engineering programs are designed according to assumptions made about the competencies of entrants into the program [17]. It is expected that students who graduate from the university still possess those entrance competencies together with the competencies conveyed through the engineering coursework [17]. The fundamental purpose of the engineering qualification is to develop a knowledge base and enable a graduate engineer to continue learning and develop engineering competencies [16]. The modern generation of engineering students have different education requirements compared to engineers of past generations [18]. The generation born during the 1990’s can be differentiated by their exposure to the fast paced and continuously improving technological age [18]. Technology forms a major part of their lives and they are comfortable using technology every day for a variety of reasons. This should be incorporated into engineering curriculum across the world [18].

The typical undergraduate engineering degree throughout the world requires that the degree meets four criteria, namely [19]:

- The growing needs for increasing liberal arts studies.
- The need to keep content as current as possible, especially with the continuous expansion of technology.
- The need to meet local accreditation requirements.
- The expressed requirements of the engineering industry, which expects a graduate engineer’s education to possess the technical skills necessary for immediate entry into the job market.
One of the major concerns is that positions which are held by engineers in their early years requires them to have both management and technical skills [19]. A graduate engineer is required to possess a certain set of attributes and to acquire sufficient competence in order to practice at an appropriate level [16]. The Engineering Council of South Africa governs the expected outcomes that universities are expected to provide to graduates through their relative engineering programmes [20]. ECSA states that the four year B.Sc. and B.Eng. Engineering degrees offered in South Africa must contain the following Exit Level Outcomes [20]: Woollacott, and others also identified these outcomes which graduate engineers are expected to be competent in [17] [21].
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<tr>
<td>1</td>
<td>Problem solving.</td>
<td>The ability to identify, formulate and solve engineering problems.</td>
<td>Mathematics, natural science and engineering sciences are applied in formal analysis and modelling of engineering situations, and for reasoning about and conceptualizing engineering problems.</td>
</tr>
<tr>
<td>2</td>
<td>Application of scientific and engineering knowledge.</td>
<td>The ability to apply knowledge of mathematics, sciences and engineering design.</td>
<td>Design problems used in exit-level assessment must conform to the definition of a complex engineering problem. A major design problem should be used to provide evidence. The design knowledge base and components, systems, engineering works, products or processes to be designed are dependent on the discipline or practice area.</td>
</tr>
<tr>
<td>3</td>
<td>Engineering design.</td>
<td>The ability to design a system, component or process to meet the desired needs.</td>
<td>The ability to design and conduct experiments and analyse and interpret data. The balance of investigation and experiment should be appropriate to the discipline. Research methodology to be applied in research or investigation where the student engages with selected knowledge in the research literature of the discipline.</td>
</tr>
<tr>
<td>4</td>
<td>Investigations, experiments and data analysis.</td>
<td>The ability to design and conduct experiments and analyse and interpret data.</td>
<td>A range of methods, skills and tools appropriate to the disciplinary designation of the program including:</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>1. Discipline-specific tools, processes or procedures;</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>2. Computer packages for computation, modelling, simulation, and information handling;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3. Computers and networks and information infrastructures for accessing, processing, managing, and storing information to enhance personal productivity and teamwork.</td>
</tr>
<tr>
<td>5</td>
<td>Engineering methods, skills and tools, including information technology.</td>
<td>The ability to use the techniques, skills and tools which are needed for engineering practice.</td>
<td>Material to be communicated is in an academic or simulated professional context. Audiences range from engineering peers, management and lay persons, using appropriate academic or professional discourse. Written reports range from short (300-1000 words plus tables diagrams) to long (10 000 to 15 000 words plus tables, diagrams and appendices), covering material at exit-level. Methods of providing information include the conventional methods of the discipline, for example engineering drawings, as well as subject-specific methods.</td>
</tr>
<tr>
<td>6</td>
<td>Professional and technical communication.</td>
<td>The ability to communicate effectively.</td>
<td>The combination of social, workplace (industrial) and physical environmental factors must be appropriate to the discipline or other designation of the qualification. Comprehension of the role of engineering in society and identified issues in engineering practice in the discipline: health, safety and environmental protection; risk assessment and management and the impacts of engineering activity: economic, social, cultural, environmental and sustainability.</td>
</tr>
<tr>
<td>7</td>
<td>Sustainability and the impact of engineering activity.</td>
<td>The broad education necessary to understand the impact of engineering solutions in a global and a social contact.</td>
<td>The combination of social, workplace (industrial) and physical environmental factors must be appropriate to the discipline or other designation of the qualification. Comprehension of the role of engineering in society and identified issues in engineering practice in the discipline: health, safety and environmental protection; risk assessment and management and the impacts of engineering activity: economic, social, cultural, environmental and sustainability.</td>
</tr>
<tr>
<td>8</td>
<td>Individual, team and multi-disciplinary working.</td>
<td>The ability to function on multi-disciplinary teams.</td>
<td>Multidisciplinary tasks require co-operation across at least one disciplinary boundary. Co-operating disciplines may be engineering disciplines with different fundamental bases other than that of the programme or may be outside engineering.</td>
</tr>
<tr>
<td>9</td>
<td>Independent learning ability.</td>
<td>Recognition of the need for, and the ability to engage in life-long learning.</td>
<td>Operate independently in complex, ill-defined contexts requiring personal responsibility and initiative, accurately self-evaluate and take responsibility for learning requirements; be aware of social and ethical implications of applying knowledge in particular contexts.</td>
</tr>
<tr>
<td>10</td>
<td>Engineering professionalism.</td>
<td>An understanding of professional and ethical responsibility.</td>
<td>Evidence includes case studies typical of engineering practice situations in which the graduate is likely to participate. Ethics and the professional responsibility of an engineer and the contextual knowledge specified in the range statement of Exit Level outcome 7 is generally applicable here.</td>
</tr>
<tr>
<td>11</td>
<td>Engineering management.</td>
<td>Knowledge of contemporary issues.</td>
<td>Basic techniques from economics, business management; project management applied to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.</td>
</tr>
</tbody>
</table>
The outcomes described in Table 1 above are specific to the four year B.Sc. and B.Eng. Engineering degrees offered in South Africa. The outcomes of these degrees are applicable to ECSA’s signatory relationship with the Washington Accord [20].

The South African engineering industry is governed by The Engineering Council of South Africa (ECSA). It is this professional regulatory body that guides an engineer’s development to professional registration. ECSA is also responsible for the governance of the engineering qualifications offered in South Africa [22]. They have their own set of expected outcomes following a student’s completion of a recognized engineering qualification. The following sub-heading will describe the expected educational outcomes of the Washington Accord that is governed by ECSA.

2.2.2. Outcomes as per the Washington Accord and governed by ECSA

The Engineering Council of South Africa (ECSA) is an institution which has been empowered by the Engineering Profession Act, 2000 (EPA) [23]. They conduct accreditation visits to educational institutions, which determine whether the engineering qualifications offered by these institutions can be recognized as per their requirements [23]. The accreditation process conducted by the EPA is carried out by an accreditation committee which checks that each program offered by the university meets the necessary criteria [23]. The International Engineering Alliance (IEA) justifies engineering degrees across the world by categorizing them into different types of qualifications. These are guided by individual accords as per Table 2 below [24] [25]:

<table>
<thead>
<tr>
<th>AGREEMENT</th>
<th>PURPOSE OF PROGRAMMES ARE TO PROVIDE THE EDUCATIONAL FOUNDATION FOR:</th>
<th>PROGRAMME TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Washington Accord</td>
<td>Engineering practice at the professional level</td>
<td>B.Sc./B.Eng.-type</td>
</tr>
<tr>
<td>Sydney Accord</td>
<td>Engineering technologist practice at the professional level</td>
<td>B.Tech.-type</td>
</tr>
<tr>
<td>Dublin Accord</td>
<td>Engineering technician practice at the professional level</td>
<td>Diploma-type</td>
</tr>
</tbody>
</table>

Table 2 – The international engineering alliance’s constituent educational agreements [24] [25] [22]

For the purposes of this research, research was only conducted on the four year B.Sc. and B.Eng. Engineering programmes. Accreditation carried out by ECSA signifies a type of formal recognition through the use of a quality assurance procedure. This states that the educational program meets the Washington Accord’s selection criteria for the four year B.Sc. and B.Eng. Engineering degrees [22] [26] [23] [25].

Both developed and developing countries around the world are in constant need of engineering services [27]. Many countries are open to professional engineering services being delivered across national boundaries [27]. Accords, such as the Washington Accord enable countries to be grouped together which eases the recognition of standards and qualifications around the world [27].

Engineering programmes in South Africa which conform to ECSA’s regulatory standards are recognized to meet the initial academic requirements for a professional engineer [22] [26]. The Washington Accord ensures that graduates are able to apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization respective to the solving of complex engineering problems [16]. ECSA requires that graduates are competent in all
exit level outcomes and it is imperative that an assessment on the competence of each student is completed [21]. Hanrahan investigated some of the related attributes which graduate engineers should be equipped with between completing an engineering degree and entering the working environment. This is identified in Figure 2 below [24]. The process shows the use of the sciences, mathematics and engineering knowledge applied to problem solving, which is an exit level outcome of the degrees [24]. A depth of contextual knowledge is required to perform problem solving and evaluate social, economic and environmental impacts of the proposed solutions [24].

Figure 2 - A concept model showing the attributes of a graduate engineer [24]

Figure 2 above shows that engineering graduates should have the ability to solve engineering problems by utilizing the skills gained during their educational journey. Graduate engineers should be able to fundamentally apply the skills gained in the engineering field and sciences to solve problems. Thereafter they should be able to evaluate these solutions.

Graduate engineers should also have the ability to utilize other skills gained during their education such as, contextual knowledge, applicable legislation, health, safety, sustainability considerations, project management
skills, financial skills, effective communication and teamwork skills in order to solve problems and evaluate solutions.

Table 3 below, presents the criteria ECSA requires for an engineering qualification. It also shows the individual assessment criteria required for an accredited program [28] [21] [25]:

<table>
<thead>
<tr>
<th>NO.</th>
<th>QUALIFICATIONS EVALUATION CRITERIA [28] [21] [25]</th>
<th>INDIVIDUAL ASSESSMENT CRITERIA [28] [21] [25]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>The programme covers the essentials of mathematics and natural science applicable to the discipline. The programme contains one semester of mathematical sciences and one semester of natural sciences.</td>
<td>The applicant displays an understanding and ability to apply the essentials of engineering in a selected discipline. The applicant does this together with the supporting fundamentals of mathematics and natural science.</td>
</tr>
<tr>
<td>1.2</td>
<td>The programme effectively covers the engineering fundamentals applicable to the discipline.</td>
<td></td>
</tr>
<tr>
<td>1.3</td>
<td>The programme covers engineering studies related to current practice in the selected engineering field.</td>
<td>The applicant displays ability in engineering specialist fields at the exit level.</td>
</tr>
<tr>
<td>2</td>
<td>The level of problem solving required at the exit level corresponds to complex engineering problems defined in ECSA document E-02-PE.</td>
<td>The applicant demonstrates proficiency in the use of engineering tools and information technology support appropriate to the discipline.</td>
</tr>
<tr>
<td>3</td>
<td>The programme contains a range of engineering tools and information technology support appropriate to the discipline.</td>
<td>The applicant demonstrates proficiency in the use of engineering tools and information technology support appropriate to the discipline.</td>
</tr>
<tr>
<td>4</td>
<td>The curriculum has the requirement for a major design exercise. The design problem meets the requirements of a complex engineering problem, and the design approach is properly structured.</td>
<td>The applicant demonstrates design proficiency is demonstrated through substantial project work. The design problem meets the requirements of a complex engineering problem, and the design approach is properly structured</td>
</tr>
<tr>
<td>5</td>
<td>The curriculum involves experimental work and research methodology.</td>
<td>The applicant demonstrates proficiency in experimental and research methodology</td>
</tr>
<tr>
<td>6</td>
<td>The curriculum requires oral and written communication at the level expected of a graduate.</td>
<td>The applicant communicates in writing at the exit level of a BEng programme</td>
</tr>
<tr>
<td>7</td>
<td>The curriculum covers elements that give an understanding of the impact of engineering activity.</td>
<td>The applicant explains and analyses impacts of engineering activity</td>
</tr>
<tr>
<td>8</td>
<td>The curriculum contains elements that give an understanding of ethics and engineering professionalism.</td>
<td>The applicant explains ethical principles and analyses ethical issues</td>
</tr>
</tbody>
</table>

ECSA is responsible for ensuring that universities deliver graduate engineers who can be recognized anywhere in the world through the Washington Accord. It is therefore not surprising that the outcomes stated in Table 3 above are similar to the outcomes stated as per Table 1 above.

ECSA affords engineers the opportunity to become recognized as professional engineers through the use of ECSA’s professional registration program. There are typically two registration processes which are applicable to graduates with four year B.Sc. and B.Eng. Engineering degrees. These are described in the section below.
2.3. **ECSA’s Professional Registration**

Graduates from accredited engineering programmes are able to practice their engineering knowledge in a globalized environment even if currently working in the local industry [28]. ECSA’s and the EPA’s accreditation system is fundamentally based on international standards. As a result, local practices work towards international benchmarks as per the International Engineering Alliance’s graduate attributes [28] [25]. ECSA encourages engineering professionals to become members of the professional engineering body. They can register as either a candidate engineer, which is usually for graduates with zero to five years of working experience or as a professional engineer who is then recognized throughout the Washington Accords signatory countries in a global capacity [28].

2.3.1. **Professional Registration and the ECSA Candidacy Program**

During a graduate engineer’s early years in the working environment they would need to undergo a period of training and obtaining experience. This experience can further develop their abilities to analyse problems, investigate and design solutions and take responsibility for their actions and decisions [29]. To do this at a professional level, an engineer should have a well-rounded set of engineering, management and communication skills [29]. They need to be able to deal with ethical, social, economic, environmental and sustainability considerations [29]. A candidate engineer must prove that they are constantly improving their knowledge [23]. They must have sufficient exposure to the engineering environment and prove that they had taken part in a structured mentoring program with competent engineers as mentors [23]. During this period a candidate engineer undergoes sufficient training and gains experience in the workplace to develop the competencies which are required [30]. The candidate engineer is expected to undergo this training under the guidance of a mentor who should preferably already be registered as a professional engineer with ECSA [29].

Woollacott developed a taxonomy table which showed what he believed professional engineering competency should entail. The IEA developed a similar table and a summary of both these tables can be viewed in Table 4 below [17] [25].
**Table 4 – A taxonomy table of what engineering competency should entail** [17] [25]

<table>
<thead>
<tr>
<th>MAJOR AREAS OF PROFICIENCY</th>
<th>SUB CATEGORIES</th>
<th>COMPETENCY AS AN ABILITY TO:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering specific work</td>
<td>General engineering work</td>
<td>Perform different aspects of any engineering work.</td>
</tr>
<tr>
<td></td>
<td>Use appropriate engineering and computer methods.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Evaluate effectiveness, productivity and profitability.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Specialist engineering work</td>
<td>Perform analytical work.</td>
</tr>
<tr>
<td></td>
<td>Perform design work.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Plan and perform investigations.</td>
<td></td>
</tr>
<tr>
<td>Engineering work mixed with other work</td>
<td>Integrate specialist engineering work appropriately.</td>
<td></td>
</tr>
<tr>
<td>Non-engineering specific work</td>
<td>General</td>
<td>Perform and execute job specific tasks.</td>
</tr>
<tr>
<td></td>
<td>Manage personal work effectively.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Support and assist ones colleagues and peers.</td>
<td></td>
</tr>
<tr>
<td>Supervision and leadership</td>
<td>Influence the performance of subordinates.</td>
<td></td>
</tr>
<tr>
<td>Management administration</td>
<td>Function as a line supervisor.</td>
<td></td>
</tr>
<tr>
<td>Communication</td>
<td>General</td>
<td>Effectively exchange, transmit and express.</td>
</tr>
<tr>
<td>Inter-personal interactions</td>
<td>General</td>
<td>Interact effectively and positively with colleagues.</td>
</tr>
<tr>
<td>Personal dispositions</td>
<td>General</td>
<td>Agreeable personal style and characteristics.</td>
</tr>
<tr>
<td></td>
<td>Disposed to consistent commitment to all job tasks.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Disposed to taking responsibility.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Interest and knowledge in contemporary issues.</td>
<td></td>
</tr>
<tr>
<td>Discipline</td>
<td>Disposed to improving personal competencies.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Understands the importance of effective learning skills.</td>
<td></td>
</tr>
<tr>
<td>Adaptive dispositions</td>
<td>Self-development</td>
<td>Able to assess ones own performance.</td>
</tr>
<tr>
<td></td>
<td>Disposed to improving critical knowledge.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Understands nature and the importance of learning skills.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Able to assess one’s own performance effectively.</td>
<td></td>
</tr>
<tr>
<td>Lifelong learning</td>
<td>Disposed to improving critical knowledge.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Understands the requirement to maintain continued competence.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Able to engage in independent life-long learning.</td>
<td></td>
</tr>
<tr>
<td>Change management</td>
<td>Able to manage the impact of change effectively.</td>
<td></td>
</tr>
</tbody>
</table>

Similar to ECSA’s candidacy program, Table 5 above shows the research Woollacott conducted. He developed a taxonomy table through his research which showed what he considered as competency measurement skills for engineers wanting to register as professional engineers. This set of competency skills is very similar to the set required by ECSA. It can be said that as long as a graduate engineer is capable of sufficiently performing the above abilities, they will be able to register as a professional engineer with ECSA.

After researching the expected capabilities of graduate engineers and the requirements of ECSA, the capabilities expected from professional engineers were considered. An evaluation was done by looking at each of the expected outcomes and capabilities.
In ECSA’s terminology “Professional competence means having the attributes necessary to perform the activities within the profession to the standards expected in independent employment or practice [30] [31].” A candidate engineer is expected to be fully competent in each of the following groups in order to satisfy the competency standards required [30] [31] [29] [23] [25] [32]. The training period which a graduate engineer would undertake in aiming to register as a professional engineer is described in Table 5 below [30]. During this period of training and gaining experience, the candidate must be employed in the engineering industry and be working under the supervision of qualified engineers [30] [31].
<table>
<thead>
<tr>
<th>GROUP</th>
<th>DESCRIPTION</th>
<th>OUTCOME</th>
<th>NATURE OF WORK</th>
<th>RESPONSIBILITY LEVELS OF A GRADUATE IN THE WORKPLACE</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Knowledge based engineering problem solving.</td>
<td>Outcome 1</td>
<td>To be able to define, investigate and analyse engineering problems.</td>
<td>Induction/ observation (Being exposed)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Outcome 2</td>
<td>To be able to design and/or develop solutions to engineering problems.</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Outcome 3</td>
<td>To be able to comprehend as well as apply knowledge; principles, specialist knowledge, jurisdictional and local knowledge.</td>
<td>Explains challenges and solutions</td>
</tr>
<tr>
<td>B</td>
<td>Managing engineering activities.</td>
<td>Outcome 4</td>
<td>To be able to manage a part of or all of one or more engineering activities.</td>
<td>Performing under close supervision (Assisting)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Outcome 5</td>
<td>To be able to communicate clearly with others in the course of relevant engineering activities.</td>
<td>Limited for work output</td>
</tr>
<tr>
<td>C</td>
<td>Impacts of engineering activities.</td>
<td>Outcome 6</td>
<td>To be able to recognize and address the reasonably foreseeable cultural, social and the environmental effects of engineering activities.</td>
<td>Performing under limited supervision (Participating)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Outcome 7</td>
<td>To be able to meet all of the legal and the regulatory requirements, as well as protect the health and safety of all persons in the course of relevant engineering activities.</td>
<td>Full for supervised work</td>
</tr>
<tr>
<td>D</td>
<td>Exercising judgement, taking responsibility and acting ethically.</td>
<td>Outcome 8</td>
<td>To be able to conduct engineering activities ethically.</td>
<td>Performing with approval of work output (Contributing)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Outcome 9</td>
<td>To be able to exercise sound judgement in the course of engineering activities.</td>
<td>Full to supervisor for immediate quality of work</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Outcome 10</td>
<td>To be responsible for making decisions on part of or all of engineering activities.</td>
<td>Candidate articulates own reasoning and compares</td>
</tr>
<tr>
<td>E</td>
<td>Continuing professional development.</td>
<td>Outcome 11</td>
<td>To be able to undertake the professional development activities which are sufficient to maintain and extend his or her engineering competence.</td>
<td>Working without supervision (Performing)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>RESPONSIBILITY</th>
<th>LEVEL OF SUPPORT</th>
<th>TYPICAL TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>6 – 12 months</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>12 – 18 months</td>
</tr>
</tbody>
</table>

Table 5 – Development period of a graduate engineer [31] [30] [29] [23] [25] [32]
Table 5 above gives a detailed description of what is typically required from graduate engineers once they begin their careers and start to develop themselves into professional engineers. The table describes the skills which graduate engineers should be equipped with, and couples it with the ECSA exit level outcomes. The ECSA development period is typically run over three years and aims to develop graduate engineers during this period.

The development process shown in Table 5 above and the expected responsibility levels of a graduate engineer in the working environment can be illustrated. A graduate engineer would typically begin with little to no responsibility. During this time they would focus their development at being exposed to the engineering world, whilst being mentored by, and assisting senior professionals in their organization.

Following this period, the graduate’s level of responsibility would gradually increase to actively participating and contributing to the company. They would start taking responsibility for specific roles in the organization, whilst under a low amount of supervision from senior professionals.

The final phase of development into a professional engineer occurs when the graduate undergoes a period of performing independently with very little guidance from senior professionals.

A breakdown of Table 5 above focusing on time required in comparison to a graduate engineers level of responsibility in the workplace is shown in Figure 3 below.

<table>
<thead>
<tr>
<th>OBSERVING</th>
<th>PERFORMING UNDER CLOSE SUPERVISION</th>
<th>PERFORMING UNDER LIMITED SUPERVISION</th>
<th>PERFORMING WITH APPROVAL OF WORK OUTPUT</th>
<th>WORKING RESPONSIBLY WITHOUT SUPERVISION</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 – 12 Months</td>
<td>12 – 24/30 Months</td>
<td>24/30 – 36/42 Months</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

From Figure 3 above it can be stated that for each of the eleven ECSA level outcomes a graduate engineer must begin their learning curve as an observer of a senior professional. The graduate engineer should start working under full supervision and then gradually work independently. It is important to note that the time period provided by ECSA for each of the responsibility levels should be adhered to at all times. This would provide the graduate with the utmost power of developing his or her skills in the field of engineering.

2.4. Evaluation of Expected Graduate Capabilities and Expected Professional Registration Capabilities

Table 6 below, combines the outcomes expected from graduate engineers and the expected capabilities of a professional engineer registered with ECSA. It can be noted that some of the education exit level outcomes are not
required for accreditation of the engineering program; however it is required by ECSA for registration as a professional engineer.

- ECSA does not expect a university engineering program to provide the outcomes of an independent learning ability and to demonstrate engineering professionalism.
- ECSA does require engineers to possess these abilities when registering as a professional engineer.

It is expected that all the education exit level outcomes are developed through sufficient working experience. This assists in the engineer’s development from graduation to professional registration.
<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Attributes of a Graduate Engineer [24]</th>
<th>ECSA’s Expected Outcomes for an Engineering Program &amp; a Graduate Engineer [28] [21] [25]</th>
<th>ECSA Competency for Professional Registration (Candidacy Program) [31] [30] [29] [23] [25] [32]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Problem solving.</td>
<td>Problem solving.</td>
<td>The individual displays a complete understanding of and has the ability required to apply the fundamentals of engineering coupled with the fundamentals of mathematics and sciences.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Engineering design.</td>
<td></td>
<td>The individual demonstrates sufficient skills in engineering design work.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Investigations, experiments and data analysis.</td>
<td></td>
<td>The individual demonstrates proficiency in research work and experimental work.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Engineering methods, skills and tools, including information technology.</td>
<td>Project management and finance.</td>
<td>The individual displays proficiency in the engineering field at exit level.</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Professional and technical communication.</td>
<td>Communication and ethics.</td>
<td>The individual is able to communicate sufficiently in writing.</td>
<td>Managing engineering activities.</td>
</tr>
<tr>
<td>7</td>
<td>Sustainability and the impact of engineering activity.</td>
<td>Contextual knowledge, Social knowledge, Cultural knowledge, Legislation, health &amp; safety, environment &amp; Sustainability.</td>
<td>The individual explains clearly and analyses the impacts of engineering activities.</td>
<td>Impacts of engineering activities.</td>
</tr>
<tr>
<td>8</td>
<td>Individual, team and multi-disciplinary working.</td>
<td>Teamwork.</td>
<td></td>
<td>Managing engineering activities.</td>
</tr>
<tr>
<td>9</td>
<td>Independent learning ability.</td>
<td></td>
<td></td>
<td>Continuing professional development.</td>
</tr>
<tr>
<td>10</td>
<td>Engineering professionalism.</td>
<td></td>
<td>Exercising judgement, taking responsibility and acting ethically.</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Engineering management.</td>
<td></td>
<td></td>
<td>Managing engineering activities.</td>
</tr>
</tbody>
</table>

Table 6 – Comparison of Expected Graduated Capabilities & the Capabilities of a Professional Engineer [17] [20] [21] [24] [28] [21] [25] [31] [30] [29] [23] [25] [32]
Upon reviewing the data in Table 6 above, it can be recognized that a need for the development of skills exists between a graduate engineer completing their university education and registering as a professional engineer.

Skills such as individual, team and multi-disciplinary working, independent learning ability, engineering professionalism and engineering management are skills amongst the skills to be developed when the graduate engineer registers as a professional engineer. These skills are to be developed by the individual through gaining sufficient working experience.

There is a link between the expected capabilities of a graduate engineer and the required capabilities of a professional engineer. It can be stated that between the expected outcomes following university and the expected outcomes from ECSA for professional registration, there is a development of skills which needs to be conducted once graduate engineers enter the workplace. Graduate engineers should be provided with the necessary opportunities in the workplace to develop themselves into professional engineers.

The question must then be asked, whether graduate engineers are being provided with the opportunities they require to develop themselves into professional engineers when they enter the workplace. Figure 4 below depicts the skills which graduate engineers are expected to develop in the workplace.

**Figure 4 – Skills to be developed through working experience**
The following sections will focus on the importance of development and how graduate engineers are being developed. Each of the skills and capabilities from Figure 4 above should be developed in graduate engineers whilst under supervision from senior professionals. They are expected to be developed to a point whereby graduates are able to successfully operate independently within a 3 year period.

There are various methods which graduate engineers can use to develop themselves through to professional registration. For the purposes of this research, methods on closing this development gap by universities, professional bodies and companies will be discussed.

2.5. Methods Used to Develop Graduate Engineers

2.5.1. Overview

A large number of employers tend to be dissatisfied with the overall communication skills of engineering graduates. Previous research has not been completely able to provide sufficient information on how to bridge the gap of incorporating workplace communication into the engineering curriculum [33]. One way to bridge this gap is for educators at tertiary institutions to be fully knowledgeable of the communication skills required in the industry, so that it can be incorporated into coursework [33].

Ruff and Carter identified specific communication skills which are applicable to engineers and the way they communicate in the workplace [33]. They established that engineers should be able to; design communication, clearly explain, discuss productively, receive communication in good terms, communicate professionally and use common forms and tools [33]. They concluded that an efficient way of enabling engineers to develop their communication skills is to encourage educators at university to respond to students as professional engineers [33].

Employers often expect engineers to possess technical engineering skills and a set of soft skills. These include; communication, teamwork, management skills and entrepreneurial skills [34]. “Research on the soft-skills which is displayed by engineering graduates confirms that tertiary institutions often send out robots and not the human beings that they would prefer [21].” The ability to communicate with other human beings is becoming increasingly lost in a modern technology driven society, as more time is being spent on communicating with electronic devices instead of with people [21]. Soft skills are becoming increasingly important in the eyes of engineering firms seeking to employ graduate engineers [21].

A major gap recognized, relating to the development of graduate engineers is problem solving, communication and teamwork skills [11] [35] [36]. Research found that some employers regarded professionalism, management/leadership and practical engineering skills as a further requirement to the above [35] [36].
2.5.2. Development through the use of Professional Bodies

Professional engineering bodies in their areas of authority such as ASCE in the United States of America and ECSA in South Africa, have specific criteria in the relevant engineering field for admission into the practice of engineering at the professional level [23]. Other engineering bodies in South Africa such as the SAIEE, ASCE in the United States of America and Engineers Ireland require their graduate engineers to attain sufficient experience in their field prior to registration as a professional engineer [37] [38] [39] [40]. These engineering bodies assist graduate engineers by providing capable mentors through their resources which can assist graduates in their development [37] [38] [39] [40]. The SAIEE has a mentorship service within the electrical engineering discipline that financially covers the training of mentors. This assists the body in ensuring that mentors are equipped with the skills required for the effective training and development of their graduate engineers [37].

Another professional body in South Africa which assists graduate engineers in ensuring they receive sufficient mentorship and training is the Construction Education and Training Authority (CETA). The professional body offers a candidacy program similar to ECSA’s candidacy program [41]. This assists graduate engineers in receiving sufficient training towards the goal of professional registration [41]. CETA has begun a venture whereby they have agreed to provide the necessary funding towards professional bodies CESA, (School of Consulting Engineering) and SABTACO, (South African Black Technical & Allied Careers Organisation). They have agreed to provide support to organisations and individuals in an effort to develop their graduate engineers towards professional registration [41]. This program supports graduate engineers by providing them with assistance to receive sufficient experience within their relevant fields. As a result, this can then enable them to register as professional engineers with ECSA [41].

Table 7 below depicts some of the basic characteristics shared between mentors and interns/graduates as noted by the Department of Works in Kwa-Zulu Natal, South Africa [42]:

<table>
<thead>
<tr>
<th>PROGRAMME</th>
<th>CHARACTERISTICS</th>
<th>AIM</th>
<th>BENEFICIARY</th>
<th>MODE OF INTERACTION</th>
<th>MENTOR NEEDED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mentorship</td>
<td>Personal growth</td>
<td>Middle/senior manager</td>
<td>Personal/private</td>
<td>Senior manager</td>
<td></td>
</tr>
<tr>
<td>Internship</td>
<td>Work experience</td>
<td>Graduate</td>
<td>Individual/group</td>
<td>Middle manager</td>
<td></td>
</tr>
</tbody>
</table>

Table 7 above states that the relationship between a mentor and an intern/graduate is a personal one which is developed in a professional environment. Success for both parties requires effective communication and an understanding between each other.

The following section will describe how universities and companies have developed graduate engineers within their own local environment.
2.5.3. Development through the use of Universities & Companies

The Jet Propulsion Laboratory (JPL), at NASA developed four approaches which could be used for the development of graduate engineers into engineering professionals. These included the following [43]:

- Allowing them the freedom to observe engineering managers.
- Active mentoring.
- A self-directed study of books and articles based on engineering.
- Formal training which is sponsored by the employer.

Engineering companies in South Africa, such as Haw & Inglis embrace the opportunity to develop their graduate employees. They do this through their career development programmes which assist graduates in registering as professional engineers with ECSA [44].

The Washington University in St. Louis, University of British Columbia, University of Pennsylvania, Cornell University and the University of Minnesota offer a career mentorship program to engineering students. Graduate engineers (Alumni) currently working in engineering, provide advice to their assigned students with regards to what can be expected of them once they enter the working environment [45] [46] [47] [48] [49]. This gives the student an opportunity to prepare themselves for what is required of them once they graduate and begin working [45] [46] [47] [48] [49].

An effective method of introducing a graduate engineer to the working environment is through the use of a structured and formal orientation program, whereby a mentor is assigned to a graduate [2]. Research shows that organisations have a poor record in mentoring and developing promising graduate engineers; however there have been requests for change to this [2]. Organisations are beginning to increasingly implement their own structured mentor programmes, in an effort to retain the skills they develop in graduate engineers [13]. This is done in an effort to prevent the organization and the country from losing valuable graduate engineers to other opportunities [13]. Mentorship programmes in organisations are known to be important to graduate engineers entering the labour market. This assists them with job security and the prospect of being able to receive the correct training and development to achieve successful registration as a professional engineer [13].

Prevatt tested a model whereby students who were interested in pursuing a Master’s degree in engineering had to undertake a course where research work was a critical component of the degree [50]. This allowed the student to develop technical writing skills which could be used in the workplace. As a result the students/graduates would be considered as ‘valuable’ during an early stage in their careers [50]. The course required students to submit their writings two to three times for assessment, to emphasize the importance of good technical writing skills. It also required the instructor to not be lenient, but to mark students work according to a specific set of criteria [50]. He also noted that engineering graduates in consulting firms required high levels of communication standards and an adequate amount of on the job training is required for these graduates [50].
The University of Kwa-Zulu Natal has developed a technique whereby students are required to compile and complete a portfolio which assesses their competency of the ECSA exit level outcomes [21]. The portfolio consists of a purposeful collection of the students work and is used as an assessment tool in assessing students learning ability and technical expertise gained [21].

It should be noted that the modern world of engineering and technology is vastly different to the one which existed twenty to fifty, and even a hundred years ago [51] [52]. This modern age brings the use of rapidly changing technologies together with modern ideas from graduates who have grown up in the technological age [51] [52]. Whilst the basic fundamentals of engineering and its principles remain the same, mentors need to become aware of the changing mind-sets of graduate engineers in the modern age. They should provide them with freedom to explore their ideas whilst still achieving the goal of being able to register as a professional engineer [51] [52]. “Training on its own can produce an increase in productivity up to 24% whilst training coupled together with a structured mentoring programme can yield an improvement in productivity results of up to 88% [13].

Summarising the development research above, Table 8 below highlights the main points of discussion. It describes how professional bodies, organisations and universities are currently trying to assist graduate engineers to develop their skills and register as a professional engineer.

<table>
<thead>
<tr>
<th>PROFESSIONAL BODIES</th>
<th>ORGANISATIONS/COMPANIES</th>
<th>UNIVERSITIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Private mentorship for graduates through the professional body</td>
<td>Active mentoring from senior professionals within the organization</td>
<td>In-house mentorship for current students through the use of current graduate engineers starting their careers.</td>
</tr>
<tr>
<td>2 Professional body candidacy programs which are specific to the relative field of engineering</td>
<td>Watch/shadow senior engineering professionals in the organization</td>
<td>Industry training and development as per professional body requirements as part of the engineering qualification.</td>
</tr>
<tr>
<td>3</td>
<td>In-house graduate development programs</td>
<td></td>
</tr>
</tbody>
</table>

### 2.6. Conclusions

The Engineering Council of South Africa (ECSA) governs and regulates engineering education programmes, ensuring compliance to the international standards of the relevant accords. Following completion of an accredited engineering qualification, graduate engineers should be equipped with skills such as problem solving, application of scientific and engineering knowledge, engineering design, investigations, experiments and data analysis, engineering methods, skills and tools, including information technology, professional and technical communication, sustainability and the impact of engineering activity, individual, team and multi-disciplinary working, independent learning ability, engineering professionalism and engineering management.
An engineer will be allowed to register as professional engineer, provided they meet the necessary criteria as required by ECSA. It can be noted that a gap for the development of skills does exist between graduation and being able to successfully register as a professional engineer. It is expected that these skills are developed through working experience. Graduate engineers are expected to follow a structured development program, whereby they continue to develop the skills gained from university over a minimum of a three year period. Once the graduate engineer is successfully able to operate without supervision in each of the ECSA outcomes, they can apply to obtain professional registration with ECSA.

Methods on developing graduate engineers and providing them with the necessary training and development can be done through professional bodies, universities and organisations. Mentorship from senior engineering professionals has proven to be a major role player in the development and training of graduate engineers towards professional registration.

Chapter 3 below gives an explanation of the research methodology selected to carry out the actual industry research. Methods on the choice of research method and details on effectively carrying out the appropriate type of research method are discussed.
3. **CHAPTER 3: Research Methodology**

Chapter 3 consists of the methodology used in conducting the research required. The research methodology aims to cover the following sub-topics:

- The objectives of the research.
- The choice of research methodology.
- The sampling method and the sample selection.
- Data collection and,
- Data analysis.

Figure 5 below shows the survey design process selected after researching methods on conducting surveys [53]. It indicates the essential phases of the survey design process. This includes, specifying the research problem and questions, drafting and finalizing the sampling plan, drafting and finalizing the questionnaire and finally collecting the data required for the research.

![Survey Design Process Diagram](image)

**Figure 5 – Chosen survey design process** [53] [54]

The survey design process was chosen as per Figure 5 above. The research problem and questions were set out as described in Chapter 1. A preliminary sampling plan was then drafted to outline the selected group of potential respondents.
The next step involved preparing an outline of the questionnaire. This provided the ideas on an efficient method of drawing up the survey instrument. A final sample selection would be made resulting in the finalization of the sampling plan. The next steps would be to pre-test the questionnaire, finalize and review the questionnaire. A final review of the sampling plan and the questionnaire can then be done to ensure that the survey design process was followed diligently. Once the above is completed, the questionnaires can be sent out to respondents so that data can be collected for the research.

Table 9 below shows the seven stages of survey design and how they are applicable to this research:

<table>
<thead>
<tr>
<th>No.</th>
<th>STAGES</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Setting objectives for information collection.</td>
<td>The objectives for the collection of information consist of the main objectives of the research, i.e. The research questions as set out in Chapter 1.</td>
</tr>
<tr>
<td>2</td>
<td>Designing the survey.</td>
<td>Prior to any survey being carried out, the researcher must establish the type of survey design which they are going to use. A number of survey designs exist and each design has its own characteristics which are beneficial to different types of studies. For this research the snowball type of design method was chosen.</td>
</tr>
<tr>
<td>3</td>
<td>Preparing a reliable and valid survey instrument.</td>
<td>The survey instrument is the type of the actual document and procedure which the researcher provides to the respondents in order to get the desired knowledge they require from the research. Survey instruments can vary, depending on what is required in terms of the research from the researcher. For this research, the online questionnaire was chosen as the desired survey instrument.</td>
</tr>
<tr>
<td>4</td>
<td>Administering the survey.</td>
<td>Once the survey instrument has been designed, the instrument must then be delivered to the relevant sample so that the survey can be carried out. For this research, the survey was administered through the use of an online questionnaire.</td>
</tr>
<tr>
<td>5</td>
<td>Managing the survey data.</td>
<td>Upon receiving the completed survey instruments from respondents, data must be managed accordingly into specific groups/categories if it is applicable. With regards to this research, data was categorized into groups of engineers and managers.</td>
</tr>
<tr>
<td>6</td>
<td>Analysing the survey data.</td>
<td>Following the management of the survey data, data must then be analysed to check the responses which were received from the respondents who participated in the survey.</td>
</tr>
<tr>
<td>7</td>
<td>Reporting the results.</td>
<td>After a detailed analysis of the survey results, interpretations and conclusions should then be made by the researcher in the form of an efficient report which provides details on the results of the survey.</td>
</tr>
</tbody>
</table>

The seven stages of the survey design process used for the research are described in the sub-headings below.

### 3.1. Objectives of the Research

The primary objective of the research is to attempt to answer the research questions as set out in Chapter 1 [53][54].

1. **Research Question 1** – What levels of responsibility are engineers expected to operate at in the workplace, from the time of graduating to the time of registering as a professional engineer?
2. **Research Question 2** - What levels of responsibility do engineers actually operate at in the workplace, from the time of graduating to the time of registering as a professional engineer?

3. **Research Question 3** – How can the development of engineering skills be facilitated in the working environment to ensure that engineers operate at the appropriate levels of responsibility in order to achieve professional engineering status?

The research questions above provide a guide and a starting point for the questionnaire [54].

### 3.2. **Designing the Survey**

A survey type of methodology was chosen to conduct the research required. This is established on the fact that surveys are based on the desire to be able to collect information from a specific sample of respondents within a well-defined population [53] [56]. Surveys act as a system for collecting information so that researchers can compare different characteristics of different people [55] [56].

As per Table 9 above, a typical survey consists of seven stages. These are; setting objectives for information collection, designing the survey, preparing a reliable and valid survey instrument, administering the survey, managing and analysing the survey data and finally reporting the results [55].

The literature review (Chapter 2) above, was completed in an effort to determine answers to the research questions. A self-administered questionnaire tool was used to determine whether the suggestions from the literature review are currently being used in practice. It was also used to determine the number of engineers who are actually being effectively developed and trained towards the goal of professional registration.

The data collection tool was developed, based on the data collected through the literature review [5] [57]. Web surveys share features of both self-administered and interview administered surveys [58]. Respondents are able to control the pace at which they complete the survey and how they perceive and process the questions [58]. An important step in the survey design process is correctly selecting the desired sample for the survey process.

The next stage of the survey design process is to accurately determine the sampling plan required for the research to be conducted.

#### 3.2.1. **Sampling Method and Sample Selection**

Sampling is done as a selection of elements, based on a set of rules from a defined population [53] [59] [54]. The principle idea of survey sampling is that a properly selected random sample can accurately represent any population, no matter how large or diverse it is [59]. A sample was selected based on a nonprobability design that could include convenience, purposive, quota and snowball type examples [53] [59] [60]. Nonprobability sampling is done using subjective methods rather than a random sample [60].
For the purposes of this research, the snowball type or the purposive type of design was selected. Snowball designs are often used when the sample units are rare or hard to find. In this specific research, engineers with four year B.Sc. and B.Eng. Engineering degrees are needed to conduct this research. The main purpose of this type of sampling is to produce a sample that can be considered as a representative of a restricted population [60].

The snowball technique was used to locate other individuals who meet the required criteria for the sample. This is based on the snowball theory that people with similar characteristics associate with each other [60]. A downfall to this technique is that it does not prove how well the final sample represents the total number of people in the country who fit the required criteria [53]. We were unable to answer this question because we do not know the probability of selection and we cannot estimate the limits of sampling error due to the snowball design [53].

Another reason for choosing this design was to get an idea/an exploratory feel for the trends within the South African engineering industry. The data collection tool was applicable to engineers currently working in the industry. The sample was selected based on individuals currently residing and working in South Africa, in order to determine the current development trends of engineers in the country.

### 3.2.2. Sampling Frame & Sampling Plan

The sampling frame for the research was a single frame [59] and the sampling of respondents for the research was done using the snowball design method. For this method, engineers with four year B.Sc. and B.Eng. Engineering degree were obtained from the following areas:

- Engineering graduates in the labour market obtained from the University of Johannesburg.
- Personal colleagues in the labour market, and,
- Engineers who are members of professional engineering bodies such as SAICE, CESA & SAIMM.

The questionnaire requested respondents to forward the questionnaire to their personal colleagues. This was done in an effort to obtain a larger number of respondents for the survey. The idea for this is based on the snowball design method, which suggests that people associate with other people who have similar characteristics to themselves. In the case of this research it was assumed that four year B.Sc. and B.Eng. graduate engineers associated with other B.Sc. and B.Eng. engineers.

Figure 6 below, shows the method used in developing the sampling plan.
As per Table 9 above, once the sampling plan is drafted, the next step of the survey design process is to prepare a valid and reliable survey instrument.

### 3.3. The Survey Instrument

“The survey questionnaire is the conduit through which information flows from the world of everyday behaviour and opinion into the world of research and analysis. It is the vital link to the phenomena which we wish to research [53].” As the internet type of questionnaire was chosen to collect data from individuals in the industry, it was important to ensure that only individuals who fit the selected sample would be able to complete the questionnaire [53] [54]. The survey included a brief introductory message to the survey. This explains the purpose of the research and provides instructions and contact details, should respondents have difficulty in answering any of the questions [53]. Development of the questionnaire involved the following steps [53]:

- Listing the research questions.
- Listing the survey question topics.
- Listing all required ancillary information.
- Assessing the variable list against the general plans for data analysis.
- Drafting the survey introduction letter.
- Proposing a question order.
- Revising the questionnaire, and,
Testing the questionnaire.

In choosing the layout and design of the questionnaire, it was noted from literature that the visual appearance of the questionnaire could be a vital component in receiving responses [58]. Effort was taken to ensure that the questionnaire was visually appealing, especially with any scalar questions. Questionnaires should be uncluttered to make them as easy as possible to answer [56]. Questions provided with scaled responses should typically follow the rules of having 4 scaled responses to maximise worthy response rates from respondents [54].

Development of the survey questions was done by continuously keeping in mind the process which the respondent will typically go through once they read the question. This includes, interpreting the question, recalling relevant information, deciding on an answer and finally providing an answer to the question [53]. Operationalizing the research questions as survey items forced us to be focused and specify exactly what information we expect to receive from respondents [53]. As much as possible, closed type questions were selected to obtain direct and specific answers from respondents. The advantage to this is that it provides a direct link to analyse and compare the answers received to the literature reviewed. A disadvantage of this system is sometimes found when the respondent isn’t exactly sure on the direct answer and opts for something in-between [53].

Wherever possible, specific response categories were used to denote the quantity of responses received in that area. This enabled us to quantify and perform an effective analysis on the responses received. Literature noted certain types of questions to avoid when drafting the questionnaire. Questions requiring responses in the form of an agree/disagree answer and double barrelled questions requiring responses in the form of excellent/poor answer were avoided. Research had found responses to these questions to be very commonly favoured toward agreement, regardless of the questions content [53].

3.3.1. Designing of the Questionnaire

Developing the questionnaire aims to operationalize the research questions and process followed in the survey design. The development of the questionnaire was as per the following [53] [54]:

- An introduction was provided for respondents with information on the purpose of the survey and instructions to complete the questionnaire. Contact details were also provided for the respondent should they need assistance in understanding the questions posed.
- The selection of respondents was also provided to ensure that respondents meet the requirements dictated by the sampling plan.
- Background questions were asked to determine the demographic information of respondents. This will provide an analysis in determining how far South Africa has come in developing engineering professionals from different backgrounds.
- Substantive questions that address aspects on the research goals were also asked. This accounted for most of the data collected.
The questions that form the beginning of the questionnaire should have specific traits. They should be relevant to the central topic, easy to answer, interesting, and of closed format. The questionnaire should start as being easy to answer and develop into more difficult questions. It should end with easy questions again to keep the respondents attention [59] [54]. As far as possible response formats should be standardized as it enables the researcher to easily analyse the results [56].

Questions following the beginning of the questionnaire should be grouped into specific sections. This allows respondents to get an understanding of the types of questions being asked and it provides a smooth flow of information for the research instrument [53] [59]. Respondents are found to be quickly uninterested by long and complex instructions for answering questions. Unclear instructions also deter respondents from answering questionnaires, and the following guidelines were used in designing the questionnaires [53] [59] [54]:

- Limit instruments to a maximum of 15-20 minutes.
- Pre-coding of response categories to allow for easier responding.
- Ensuring sufficient spacing for responses to open ended questions.
- Providing simple instructions.
- Using different formatting options for questions and responses.
- Avoid jargon and complex words as much as possible.

It was derived that questionnaires which required respondents to scroll down the screen to the next question resulted in a higher number of non-responses. The recommendation was to therefore place four to ten items per screen [61].

The questionnaire was designed on an online platform, i.e. Google Forms. It consisted of sections that aimed to answer the research questions. Information was requested from candidate, professional and unregistered engineers with ECSA. These questions were related to:

- The individuals engineering related work experience since graduation,
- The time taken to obtain professional registration with ECSA,
- Their levels of responsibility in the workplace and,
- If they were following any formal development programs to help them achieve professional engineering status with ECSA.

A complete copy of the final questionnaire can be seen under Appendix A and the online link to the questionnaire is provided below.

https://docs.google.com/forms/d/1VoxxaUjIPEoVcJiHPdef-ZQOOh21R1qTed4dd6hKX0/viewform?usp=send_form
Once the survey instrument was completed, reviewed and pre-tested, the next phase of the survey design process was to administer the survey to the selected sample and to collect the required data from the industry.

3.4. Administering the Questionnaire – Data Collection

The questionnaire was developed online and a link to the questionnaire was emailed to the individuals in the sample. The questionnaire was developed to target engineers who were either candidate engineers or professional engineers registered with ECSA. It consisted of 16 questions for candidate engineers, 15 questions for professional engineers and 15 questions for un-registered engineers with ECSA. The survey was designed to achieve the research objectives.

It was determined that closed-ended types of questions would be best suited to the research. It allowed the researcher to analyse the responses and deduct conclusions from the responses received. These types of questions would be used as far as possible [53] [59] [54] [55]. Closed ended questions provided respondents with pre-selected answers to choose from. These questions are usually harder to write, however they provide responses which can be analysed statistically [56]. Open ended questions could also be used as they allow respondents to answer questions in their own words. This makes analysing the data more challenging as each respondent may have different answers and comparing data could be more difficult [56].

The data collection strategy can greatly influence the quality of the data, and is a characteristic of the credibility of the data [54]. It was important to collect the data in an efficient manner through the use of the self-administered survey [54]. Internet type surveys were chosen as it was predicted to be an efficient form of data collection. In comparison to mailed questionnaires, telephone interviews and face to face interviews [53]. Some advantages include [53]:

- They are cost-effective.
- It can span over a larger geographical area with no additional cost.
- The data collection period would be very short when compared to other methods of data collection, and,
- It would be the most convenient method for respondents.

The biggest disadvantage to this type of data collection tool is that there is a possibility that not everyone will have complete access to the internet [53]. It is predicted that as the sample chosen is predominantly based on individuals currently in the labour market, all respondents would have access to the internet. Another disadvantage with internet surveys is that they could potentially have low rates of response if the questionnaires were too long and if questions were too complex [53].

Every effort was taken to ensure that the questionnaire was kept to a maximum required responding time of 15-20 minutes and that the questions were easily understood by the respondents.
3.5. **Managing the Surveyed Data**

Once the data has been collected from respondents, it is important to manage and sort the received data in a categorical manner according to what is required in terms of the research. For the purposes of this research, data will be managed and sorted into three fundamental categories, i.e. Engineers who are currently registered as candidate engineers with ECSA, professionally registered engineers with ECSA and engineers not registered with ECSA. These three categories will help determine the trends of registration with ECSA.

It will assist in determining the trends of how candidate engineers are currently promoting their development in the workplace to achieve professional registration. It will also assist in determining how professional engineers have developed their skills in the workplace to gain the professional status.

3.6. **Data Analysis**

The next point is an analysis of the data collected. Data collection needs to be done in a logical method. Survey data needs preparation, data cleaning and data entry [54]. Questionnaire responses should be proofread prior to analysis. Guidelines should be created on how to analyse unclear responses [54]. The following steps will be executed to analyse the data received from respondents [54] [62]:

- Export the data into a Microsoft Office, Excel format for analysis.
- Proofread completed questionnaires and decide how to analyse unclear responses.
- Filter the relevant data received during the analysis.
- Complete aggregation of items responses.
- Analyse the main variables and compare between the different questions asked.

An easy method of reporting the results of the survey is through the use of concise, quality lists [62]. Other methods of reporting on the results include the use of charts and tables [62].

3.7. **Reporting the Results**

Following the analysis on the data received, interpretation and descriptive reporting on the results will then be discussed and is shown in Chapter 4 below.

3.8. **Conclusions**

The primary objective of the survey design process is to find solutions to the research questions. The survey design process consisted of specifying the research problem and research questions, drafting a preliminary sampling plan, preparing a questionnaire, finalizing the sample and the questionnaire, pre-testing the questionnaire, reviewing the survey process and finally collecting the data.

A self-administered web-survey is the chosen survey method for collecting the data required. The snowball or purposive type of design was chosen in selecting the sample for the survey. The sampling plan consisted of four
year of B.Sc. and B.Eng. Engineering degree professionals in the labour market, from; the University of Johannesburg, personal colleagues and members of professional engineering bodies. Respondents were asked to refer the questionnaire to their own friends and colleagues in an effort to gain a larger response rate.

The questionnaire consisted of 5 sections, of which respondents would only complete 3. This includes demographic information, career information and information dependant on their registration status with ECSA. Once the data had been collected, the data would be analysed, managed and would then be prepared to report the results in a clear manner.

Chapter 4 below discusses the results of the actual industry research and provides a detailed analysis on these results. These results will assist in determining answers to the problem statement and to the research questions stated in Chapter 1.
4. CHAPTER 4: Research Results

This chapter illustrates the results and the analysis of the research conducted in the survey.

4.1. Survey Background

The purpose of the survey is to determine trends in South Africa with regards to the professional registration with ECSA of B.Sc. and B. Eng. Engineering professionals. The survey targeted respondents from the following categories of the engineering industry:

- B.Sc. and B.Eng. candidate and unregistered engineers in the South African labour market.
- B.Sc. and B.Eng. professional engineers in the South African labour market.

This chapter will cover the results of the survey conducted by presenting the data collected in an easily readable format and providing detailed descriptions with the regards to the responses received.

The survey commenced on the 23rd February 2016 and was closed on the 16th March 2016, running for a total of 23 days. A total number of 811 respondents answered the survey during this time.

In 2015, ECSA released its annual report stating that at the time they had a total number of 24 325 candidate and professional engineers registered [63]. Assuming that there hasn’t been a large change in this number, the 811 respondents for this survey potentially represent about 3.3% of the registered candidate and professional engineering population in South Africa.

It is acknowledged that this value of 3.3% represents a very low number of engineers in South Africa and care should be taken with the generalization of results. For the purposes of determining trends in South Africa regarding engineers, this was assumed to be sufficient.

Respondents came from a variety of different age groups and different engineering industries. The research results are discussed in the sections below.

4.2. Respondents Age and Gender Profile

The questionnaire required respondents to select information stating the age group they fall into. The respondents’ age groups were used to determine trends with regards to their professional registration with ECSA following their graduation. All 811 respondents answered this question.
From Figure 7 above, it can be derived that there was a consistent response rate received, amongst each of the age groups. The responses provided a valuable representation of the trends for each of these age groups. These responses are discussed throughout this chapter. It was expected that there would be a very low response rate for respondents aged 20 years old and younger as the questionnaire was based around graduate and senior engineering professionals. There was a very adequate split in respondents between the different age groups, namely the 21-29 years, 30-39 years old and 60 years old and older groups.

A lower number of respondents came from the age groups between 40-49 & 50-59 years old with 14% and 15% respectively, coming from these age groups. This provided an understanding that trends of candidate and professional engineers in South Africa could be adequately reflected for each of the age groups.

The questionnaire also determined the gender of the respondents. The respondents’ genders were used to determine trends in the engineering industry with regards to male and female engineers and their registration status with ECSA. All 811 respondents answered this question.
A total of 87% of respondents were male and a total of 13% of respondents were female as shown in Figure 8 above. As the engineering industry is known to be a male dominated industry, the response balance between male and female genders received, was as expected.

A further breakdown of respondents as per their age groups and their gender can be seen in the Table 10 below.

<table>
<thead>
<tr>
<th>AGE GROUP</th>
<th>TOTAL No. Respondents</th>
<th>MALE (No.)</th>
<th>FEMALE (No.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Younger than 20 years old</td>
<td>1 (0%)</td>
<td>0</td>
<td>1 (0%)</td>
</tr>
<tr>
<td>21 - 29 years old</td>
<td>192 (24%)</td>
<td>136 (17%)</td>
<td>56 (7%)</td>
</tr>
<tr>
<td>30 - 39 years old</td>
<td>194 (24%)</td>
<td>161 (20%)</td>
<td>33 (4%)</td>
</tr>
<tr>
<td>40 - 49 years old</td>
<td>119 (14%)</td>
<td>107 (13%)</td>
<td>12 (2%)</td>
</tr>
<tr>
<td>50 - 59 years old</td>
<td>121 (15%)</td>
<td>120 (15%)</td>
<td>1 (0%)</td>
</tr>
<tr>
<td>60 years old and older</td>
<td>184 (23%)</td>
<td>183 (22%)</td>
<td>1 (0%)</td>
</tr>
<tr>
<td><strong>TOTALS</strong></td>
<td><strong>811 (100%)</strong></td>
<td><strong>707 (87%)</strong></td>
<td><strong>104 (13%)</strong></td>
</tr>
</tbody>
</table>

From Table 10 above, a good indication can be noted that the trend in South Africa is currently changing with the younger age group and that more females are joining the engineering industry.

4.3. **Highest Qualifications Obtained & Dates of Graduation**

Respondents were asked to provide information on their academic qualifications. Figure 9 below shows the responses received. Only 807 out of 811 respondents answered this question, with 4 respondents leaving this question blank.

As the questionnaire was aimed at engineers who are currently in possession of B.Sc./B.Eng. Engineering and Honours degrees, it was expected that a large portion of respondents would have selected this option. This is
illustrated in Figure 9 above, with a total of 503 (62%) respondents selecting this option. 184 (23%) respondents possessed degrees of a higher level, namely Masters and Doctoral Engineering degrees.

71 (9%) respondents selected that they possessed another type of degree and these respondents could have been eligible to participate in the survey. This was dependent on their registration status with ECSA.

49 (6%) respondents selected that they possess B.Tech. Engineering degrees. They were allowed to participate in the unregistered engineers section of the survey, as the research was aimed at candidate and professional engineers, and not engineering technologists.

The questionnaire requested respondents to provide the dates in which they had obtained their highest qualifications. The results of this question were summarized into groups of years and can be seen in Figure 10 below. All 811 respondents answered this question.

Figure 10 – Years in which Respondents obtained their highest qualifications

Figure 10 above, displays a good representation (12% or more) from respondents who have obtained their qualifications over the 72 year span. As per Chapter 2, Section 2.3, of the literature review, a graduate engineer is expected to register with ECSA during their early years after graduation, with the aim of obtaining professional registration 36 months later.

4.4. Industry Representation

Respondents were requested to provide the types of industries in which they currently work in. Figure 11 below shows the responses received. Only 808 out of 811 respondents answered this question, with 3 respondents leaving this question blank.
SAICE agreed to send the survey link to their registered members, and this could be the reason for the large number of respondents from the Construction and Civil Engineering industry. It is important to note that there were no respondents from the Retail & Wholesale and the Technology, Media & Entertainment industries.

4.5. ECSA Registration Status & Reasons for Non-Registration

4.5.1. ECSA Registration Status

The questionnaire asked respondents to provide their ECSA registration status. Figure 12 below shows the responses received. All 811 respondents answered this question including those whose results were ineligible for the survey.
632 (78%) respondents are currently registered with ECSA. This provided a good foundation for an analysis of registered engineers. There were a larger number of registered respondents compared to the number of respondents not registered with ECSA. A large portion of 179 (22%) respondents are not registered with ECSA, and this provided a basis to investigate trends in South Africa regarding engineers not registered with ECSA.

Taking Figures 10 and 12 into account, Table 11 below shows the years in which respondents obtained their highest qualifications, and compares it to the respondents’ registration status with ECSA.

<table>
<thead>
<tr>
<th>YEAR OF OBTAINING DEGREE</th>
<th>TOTAL No.</th>
<th>REGISTERED WITH ECSA</th>
<th>NOT REGISTERED WITH ECSA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Candidate Engineer</td>
<td>Professional Engineer</td>
</tr>
<tr>
<td>2010 - 2016</td>
<td>279 (34%)</td>
<td>121 (15%)</td>
<td>55 (7%)</td>
</tr>
<tr>
<td>2000 – 2009</td>
<td>187 (23%)</td>
<td>44 (5%)</td>
<td>80 (10%)</td>
</tr>
<tr>
<td>1990 – 1999</td>
<td>117 (15%)</td>
<td>2 (0%)</td>
<td>94 (12%)</td>
</tr>
<tr>
<td>1980 – 1989</td>
<td>97 (12%)</td>
<td>6 (1%)</td>
<td>73 (9%)</td>
</tr>
<tr>
<td>1944 - 1979</td>
<td>131 (16%)</td>
<td>0 (0%)</td>
<td>116 (14%)</td>
</tr>
<tr>
<td>TOTALS</td>
<td>811 (100%)</td>
<td>173 (21%)</td>
<td>418 (52%)</td>
</tr>
</tbody>
</table>

From these statistics it can be revealed that no matter the time period in which respondents obtained their highest qualifications, there are more respondents that tend to register with ECSA rather than not register. It can also be revealed that within the group who obtained their highest qualifications relatively recently, there is still a large portion of engineers who are not registered with ECSA, when compared to respondents who obtained their qualifications a longer time ago.

4.5.2. Date of ECSA Registration

Respondents who stated that they are currently registered with ECSA were asked to state the dates in which they had initially registered with ECSA. The response dates were categorized into groups of years and is shown in Figure 13 below. As per Figure 12, a total of 632 out of 811 respondents who selected that they are registered with ECSA answered this question.
From Figure 13 above, it can be stated that registration with ECSA is becoming a common trend amongst engineers.

- As respondents were requested to state the dates in which they obtained their highest qualifications, and initially registered with ECSA, it was difficult to establish how soon after obtaining their graduate B.Sc./B.Eng. Engineering and Honours degrees, did respondents actually register with ECSA.
- For this purpose Table 12 below was compiled and was based on respondents who only had the B.Sc./B.Eng. Engineering and Honours degrees. This was 503 out of 811 (62%) respondents.
- Respondents with Masters and Doctoral Engineering degrees were excluded from the comparison below, as they could have obtained these qualifications after already working in the industry and being registered with ECSA.

Table 12 - Registration with ECSA based on year of obtaining graduate degree

<table>
<thead>
<tr>
<th>YEAR OF OBTAINING DEGREE</th>
<th>TOTAL No.</th>
<th>REGISTERED WITH ECSA</th>
<th>NOT REGISTERED WITH ECSA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Candidate Engineer</td>
<td>Professional Engineer</td>
</tr>
<tr>
<td>2010 - 2016</td>
<td>170 (34%)</td>
<td>98 (19%)</td>
<td>23 (5%)</td>
</tr>
<tr>
<td>2000 – 2009</td>
<td>118 (23%)</td>
<td>35 (7%)</td>
<td>48 (10%)</td>
</tr>
<tr>
<td>1990 – 1999</td>
<td>60 (12%)</td>
<td>2 (0%)</td>
<td>49 (10%)</td>
</tr>
<tr>
<td>1980 – 1989</td>
<td>58 (12%)</td>
<td>0 (0%)</td>
<td>47 (9%)</td>
</tr>
<tr>
<td>1944 - 1979</td>
<td>97 (19%)</td>
<td>0 (0%)</td>
<td>86 (17%)</td>
</tr>
<tr>
<td>TOTALS</td>
<td>503 (100%)</td>
<td>138 (27%)</td>
<td>253 (51%)</td>
</tr>
</tbody>
</table>

As per Chapter 2, Section 2.3, graduate engineers should register with ECSA during the early years of their careers.

Table 12 above reveals that a large number of engineers register with ECSA after graduation. The trend from Table 12 above depicts that although most engineers register with ECSA, many candidate engineers do not obtain professional registration within the 3 years following their graduation (2010 – 2016).
4.5.3. **ECSA Registration Category**

ECSA registered respondents were then requested to provide what category they were registered in with ECSA. Figure 14 below shows the responses received. As per Figure 12, a total of 632 out of 811 respondents who selected that they are registered with ECSA answered this question.

![Respondents Currently Registered with ECSA as](image)

**Figure 14 – Respondents currently registered with ECSA as:**

It was established that a total of 591 (93%) respondents were eligible to take part in the candidate and professional engineer sections of the questionnaire. The remaining 41 (7%) respondents were ineligible to take further part in the questionnaire as they were registered as another type of professional with ECSA which was not covered in this research, e.g. B.Tech. Engineering graduates.

These results provided a good baseline to note the trends regarding both candidate engineers and professional engineers. Just over a quarter of respondents were able to provide trends regarding their development in the labour market as candidate engineers attempting to obtain professional registration. The candidate engineers could also provide information regarding the levels of responsibility they currently operate at in the workplace.

Two thirds of respondents stated that they were registered as professional engineers. This large quantity serves as a solid foundation for determining how these engineers obtained professional registration, how long it took them to obtain professional registration and what level of responsibility they currently operate at in the workplace.

4.5.4. **Respondents Considering ECSA Registration**

Respondents who selected that they were not registered with ECSA were asked if they were considering registering with ECSA. As per Figure 12, a total of 179 out of 811 respondents who selected that they are not registered with ECSA answered this question.

- 139 of 179 (78%) respondents who had not registered with ECSA stated that they were considering registering with ECSA.
40 of 179 (22%) respondents who had not registered with ECSA stated that they were not considering registering with ECSA.

It is a positive conclusion that unregistered engineers were considering registering with ECSA in the future. It is also a negative conclusion that 22% of respondents stated that they were not interested in registering with ECSA.

4.5.5. Respondents Reasons for Non-Registrations

Respondents stated the reasons for them not registering with ECSA. Figure 15 below reveals the reason why respondents chose not to register with ECSA. As per Figure 12, a total of 179 out of 811 respondents who selected that they are not registered with ECSA answered this question.

![Figure 15 – Reasons respondents haven't registered with ECSA](image)

From the results above it can be noted that a total of 47% of respondents who are currently not registered with ECSA had the desire to register with ECSA. This provided a variance of 31% in the results from section 4.5.4., where 78% of respondents stated that they were considering registering with ECSA soon.

A large number of 53% of respondents stated concerning reasons, for having not registered with ECSA.

Comparing these results to Figure 11 which shows the respondents industry representation, the following can be noted as per Table 13 below.
Table 13 – Respondents reasons for not registering with ECSA vs. the industry they work in

<table>
<thead>
<tr>
<th>INDUSTRY</th>
<th>DON’T UNDERSTAND THE REGISTRATION PROCESS</th>
<th>NOT INTERESTED IN REGISTERING</th>
<th>NOT A REQUIREMENT/NECESSITY</th>
<th>I AM CONSIDERING REGISTERING WITH ECSA SOON</th>
<th>OTHER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information and Communications Technology (ICT)</td>
<td>1 (0.5%)</td>
<td>-</td>
<td>1 (0.5%)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Finance and Banking</td>
<td>-</td>
<td>1 (0.5%)</td>
<td>1 (0.5%)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Energy and Utilities</td>
<td>-</td>
<td>-</td>
<td>7 (4%)</td>
<td>7 (4%)</td>
<td>1 (0.5%)</td>
</tr>
<tr>
<td>Government, Public Sector &amp; Defence</td>
<td>-</td>
<td>-</td>
<td>1 (0.5%)</td>
<td>8 (4%)</td>
<td>5 (3%)</td>
</tr>
<tr>
<td>Mining &amp; Commodities</td>
<td>4 (2%)</td>
<td>-</td>
<td>6 (3%)</td>
<td>6 (3%)</td>
<td>8 (4%)</td>
</tr>
<tr>
<td>Transport</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>6 (3%)</td>
<td>-</td>
</tr>
<tr>
<td>Retail and Wholesale</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Construction and Civil Engineering</td>
<td>3 (2%)</td>
<td>5 (3%)</td>
<td>2 (1%)</td>
<td>23 (13%)</td>
<td>6 (3%)</td>
</tr>
<tr>
<td>Consulting or professional services</td>
<td>5 (3%)</td>
<td>1 (0.5%)</td>
<td>6 (3%)</td>
<td>29 (16%)</td>
<td>11 (6%)</td>
</tr>
<tr>
<td>Fast Moving Consumer Goods (FMCG)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>TMT (Technology, Media and Entertainment)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Other</td>
<td>6 (3%)</td>
<td>1 (0.5%)</td>
<td>7 (4%)</td>
<td>5 (3%)</td>
<td>6 (3%)</td>
</tr>
<tr>
<td>TOTALS</td>
<td>19 (11%)</td>
<td>8 (4%)</td>
<td>31 (17%)</td>
<td>84 (47%)</td>
<td>37 (21%)</td>
</tr>
<tr>
<td>Younger than 20 years old</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1 (0.5%)</td>
</tr>
<tr>
<td>21 - 29 years old</td>
<td>10 (6%)</td>
<td>4 (2%)</td>
<td>7 (4%)</td>
<td>43 (24%)</td>
<td>5 (3%)</td>
</tr>
<tr>
<td>30 - 39 years old</td>
<td>6 (3%)</td>
<td>3 (2%)</td>
<td>10 (6%)</td>
<td>24 (13%)</td>
<td>16 (9%)</td>
</tr>
<tr>
<td>40 - 49 years old</td>
<td>2 (1%)</td>
<td>-</td>
<td>4 (2%)</td>
<td>9 (5%)</td>
<td>4 (2%)</td>
</tr>
<tr>
<td>50 - 59 years old</td>
<td>1 (0.5%)</td>
<td>1 (0.5%)</td>
<td>6 (3%)</td>
<td>7 (4%)</td>
<td>4 (2%)</td>
</tr>
<tr>
<td>60 years old and older</td>
<td>-</td>
<td>-</td>
<td>4 (2%)</td>
<td>1 (0.5%)</td>
<td>7 (4%)</td>
</tr>
</tbody>
</table>

From Table 13 above, it can be revealed that a large number of candidate engineers who had reasons for not registering with ECSA came from the consulting or professional services industry. The largest number of candidate engineers who were considering registering with ECSA came from the very same industry.

It can also be noted that the greatest number of candidate engineers considering registering with ECSA came from the younger generation of 21-29 years old and the most number of candidates who had reasons for not wanting to register with ECSA came from the older generations.

4.6. Candidate Engineer Information

Respondents who stated that they were registered as candidate engineers were directed to Section 3 of the questionnaire. Their responses were specific and only applicable to questions relevant to candidate engineers, which can be seen below.
4.6.1. Engineering Related Working Experience

Candidate engineers were requested to state their engineering related work experience since graduation. Figure 16 below shows the responses received. As per Figure 14, the 173 respondents who selected that they were registered as candidate engineers answered this question and this showed the following:

3% of respondents had very little engineering related working experience constituting of 0-6 months. All respondents had engineering related working experience which can be compared to the literature reviewed in Chapter 2.

68% of candidate engineers who responded to the survey had 36+ months of engineering related working experience. By taking into account the literature reviewed under Chapter 2, Section 2.3, candidate engineers should be able to register as professional engineers after 36 months of working as a candidate engineer. From the results obtained in the research, this shows that 68% of candidate engineers had not obtained professional registration, when literature suggests that they should have. Table 14 below, shows this comparison to literature.

**Table 14 – Candidate engineers working experience vs. literature guidelines**

<table>
<thead>
<tr>
<th>WORKING EXPERIENCE</th>
<th>AGE GROUPS</th>
<th>LITERATURE GUIDELINES</th>
<th>ACTUAL RESULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>21 - 29 YEARS OLD</td>
<td>30 - 39 YEARS OLD</td>
<td>40 - 49 YEARS OLD</td>
</tr>
<tr>
<td>0 - 6 months</td>
<td>3 (2%)</td>
<td>2 (1%)</td>
<td>-</td>
</tr>
<tr>
<td>6 - 12 months</td>
<td>8 (4%)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>12 - 18 months</td>
<td>14 (8%)</td>
<td>1 (1%)</td>
<td>-</td>
</tr>
<tr>
<td>18 - 30 months</td>
<td>17 (9%)</td>
<td>3 (2%)</td>
<td>-</td>
</tr>
<tr>
<td>30 - 36 months</td>
<td>6 (4%)</td>
<td>2 (1%)</td>
<td>-</td>
</tr>
<tr>
<td>36+ months</td>
<td>56 (32%)</td>
<td>46 (27%)</td>
<td>9 (5%)</td>
</tr>
<tr>
<td>TOTALS</td>
<td>104 (59%)</td>
<td>54 (32%)</td>
<td>9 (5%)</td>
</tr>
</tbody>
</table>
From Table 14 above, it is clear that 68% of candidate engineers in the current industry are not obtaining professional registration with ECSA within the expected time. It can also be stated that the majority of candidate engineers who should have obtained professional registration due to their working experience, came from the two youngest generations.

A trend which can be deduced is that as candidate engineers get older, they progress onto professional registration; however this does not occur within the 3 year time period that literature suggests as per Chapter 2, Section 2.3.

4.6.2. **Estimated time to obtain Professional Registration**

Respondents were requested to provide the time they estimate will be needed to achieve professional registration with ECSA. The results of this question were summarized into groups of years and is shown in Figure 17 below. As per Figure 14, the 173 respondents who selected that they are registered as candidate engineers with ECSA answered this question.

![Figure 17](image_url)

*Figure 17 – Candidate engineers estimated time to obtain professional registration*

From Figure 17 above, it can be comprehended that there are not many candidate engineers who believe that they will achieve professional registration with ECSA within the suggested 3 year period. Only 24% stated that they would achieve this in the 3 year period.

As per literature from Chapter 2, Section 2.3, this is more than the suggested time it should take to obtain professional registration. In total there were 76% of candidate engineers who estimated that they would take longer than 3 years to obtain professional registration with ECSA. Questions from Figure 17 above can be asked as to why such a vast percentage of candidate engineers felt that they would take longer than 36 months to obtain professional registration.
4.6.3. **Actual Levels of Responsibility in the Workplace**

Candidate engineers were then requested to state the levels of responsibility they operate at in the workplace. Figure 18 below shows the responses received. As per Figure 14, the 173 respondents who selected that they are registered as candidate engineers with ECSA answered this question.

![Pie chart showing levels of responsibility](image)

**Figure 18 – Candidate engineers level of responsibility in the workplace**

The largest group of responses received for this question revealed that a total of 39% of respondents were operating at the level of operating without supervision (performing). There was a good distribution amongst respondents who were operating between the levels of participating, contributing and performing.

With reference to the literature reviewed in Chapter 2, Section 2.3, candidate engineers should be operating at specific levels in the workplace, depending on their engineering related operating experience following graduation. Further analysis on this was prepared and is shown below.

4.6.4. **Opinions on Levels of Responsibility in the Workplace**

Candidate engineers were also requested to state the levels of responsibility they feel they should be operating at in the workplace. Figure 19 below shows the responses received. As per Figure 14, the 173 respondents who selected that they are registered as candidate engineers with ECSA answered this question.
The largest group of responses received for this question show that a total of 51% of respondents felt that they should be operating at the level of working without supervision (performing). This noted concern as a number of candidate engineers stated that they should be working at different levels of responsibility compared to where they currently work. The reasons for this could be investigated in the future.

The following is a summary of the 173 candidate engineers and the levels of responsibility they feel they should be operating at in the workplace. This is shown in Table 15 below.

<table>
<thead>
<tr>
<th>WORK EXPERIENCE</th>
<th>A LEVEL BELOW THE LEVEL CURRENTLY OPERATING AT</th>
<th>A LEVEL ABOVE THE LEVEL CURRENTLY OPERATING AT</th>
<th>THE LEVEL THEY CURRENTLY OPERATE AT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-6 months</td>
<td>1 (0.5%)</td>
<td>1 (0.5%)</td>
<td>3 (2%)</td>
</tr>
<tr>
<td>6-12 months</td>
<td>-</td>
<td>2 (1%)</td>
<td>6 (3%)</td>
</tr>
<tr>
<td>12-18 months</td>
<td>-</td>
<td>5 (3%)</td>
<td>10 (6%)</td>
</tr>
<tr>
<td>18-30 months</td>
<td>1 (0.5%)</td>
<td>6 (3%)</td>
<td>13 (8%)</td>
</tr>
<tr>
<td>30-36 months</td>
<td>-</td>
<td>2 (1%)</td>
<td>6 (3%)</td>
</tr>
<tr>
<td>36+ months</td>
<td>2 (1%)</td>
<td>34 (20%)</td>
<td>81 (47%)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>4 (2%)</td>
<td>50 (29%)</td>
<td>119 (69%)</td>
</tr>
</tbody>
</table>

The results depicted in Table 15 above raises concerns as to why 31% (29% + 2%) of candidate engineers feel that they should be operating at different levels to the ones they currently operate at. This also raises the question of whether these engineers are being given the correct support mechanisms in the workplace to progress to the next levels of their careers.
As per Table 5, Chapter 2 above, ECSA states that candidate engineers should undergo a specific training period, especially during the early years of their careers. They should be working at specific levels in the workplace and based on this, the following analysis was done.

- As respondents were requested to state the dates in which they obtained their highest qualifications, and initially registered with ECSA, it was difficult to establish how soon after obtaining their graduate B.Sc./B.Eng. Engineering and Honours degrees, did respondents actually register with ECSA.
- For this purpose Table 16 below was compiled and was based on respondents who only had the graduate B.Sc./B.Eng. Engineering and Honours degrees. This was 138 out of 173 (80%) respondents.
- Respondents with Masters and Doctoral Engineering degrees were excluded from the comparison below, as they could have obtained these qualifications after already working in the industry and being registered with ECSA.
- It was assumed that graduate engineers will begin their careers in the year following their graduation, and thus the following can be derived.

Table 16 – Expected vs. actual operating levels in the workplace

<table>
<thead>
<tr>
<th>PHASES OF DEVELOPMENT PERIOD OF A GRADUATE ENGINEER FROM LITERATURE</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>OBSERVING</td>
<td>PERFORMING UNDER CLOSE SUPERVISION</td>
<td>PERFORMING UNDER LIMITED SUPERVISION</td>
<td>PERFORMING WITH APPROVAL OF WORK OUTPUT</td>
<td>WORKING RESPONSIBLY WITHOUT SUPERVISION</td>
</tr>
<tr>
<td>6 – 12 Months</td>
<td>12 – 30 Months</td>
<td>30 – 36+ Months</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RESPONDENTS EXPECTED LEVELS OF RESPONSIBILITY DERIVED FROM DATES OF GRADUATION</td>
<td>11 (8%)</td>
<td>19 (14%)</td>
<td>108 (78%)</td>
<td></td>
</tr>
<tr>
<td>RESPONDENTS EXPECTED LEVELS OF RESPONSIBILITY DERIVED FROM ACTUAL WORKING EXPERIENCE</td>
<td>11 (8%)</td>
<td>30 (22%)</td>
<td>97 (70%)</td>
<td></td>
</tr>
<tr>
<td>RESPONDENTS ACTUAL LEVELS OF RESPONSIBILITY BASED ON RESPONDENTS ACTUAL SELECTION</td>
<td>6 (4%)</td>
<td>47 (34%)</td>
<td>85 (62%)</td>
<td></td>
</tr>
<tr>
<td>RESPONDENTS OPINIONS ON LEVELS OF RESPONSIBILITY BASED ON RESPONDENTS ACTUAL SELECTION</td>
<td>1 (1%)</td>
<td>73 (53%)</td>
<td>64 (46%)</td>
<td></td>
</tr>
</tbody>
</table>

Table 16 above shows the percentage of candidate engineers and the levels of responsibility they should be operating at in the workplace. This is based on their dates of graduation and their actual working experience.

- For the results below, the derived results from actual working experience were used and not from dates of graduation. Comparing this to the responses received showed the following:
8% of respondents were expected to be operating at the levels of observing and performing under close supervision. Only 4% of respondents were actually operating at these levels and only 1% of respondents felt that they should be operating at these levels.

22% of respondents were expected to be operating at the levels of performing under limited supervision and performing with approval of work output. 34% of respondents were actually operating at these levels and 53% of respondents felt that they should be operating at these levels.

70% of respondents were expected to be operating at the level of operating responsibly without supervision. Only 62% of respondents were actually operating at this level and only 46% of respondents felt that they should be operating at this level.

It can be stated that phases 1, 2 & 5 showed a lower actual response rate received than what was expected and phases 3 & 4 showed a higher actual response rate than expected.

A concern from this can be raised as to why so many candidate engineers felt that they do not have the confidence to operate at the level of operating responsibly without supervision.

4.6.5. Reasons for Not Operating At the Correct Levels

Candidate engineers had to state what is preventing them from operating at the levels of responsibility which they feel they should be operating at in the workplace. The results of this question were summarized into groups of and can be seen in Figure 20 below. As per Figure 14, the 173 respondents who selected that they are registered as candidate engineers with ECSA answered this question.

Figure 20 – Summary of reasons candidate engineers were not operating at their preferred levels

- 71 (41%) Nothing (Candidate Engineers are operating where they feel they should be operating)
- 43 (25%) Company not providing sufficient experience/training to the candidate engineer in order to assist them in obtaining professional registration
- 40 (23%) Candidate not yet registered as a Professional Engineer with ECSA
- 14 (8%) Candidate engineer working or has worked in the wrong industry
- 5 (3%) Option to comment left Blank
The majority of candidate engineers chose to leave this option blank and to state that they were operating at the levels they felt they should be operating at in the workplace. The next biggest contributor to Figure 20 above came from candidate engineers who were not being developed effectively because of reasons occurring in the workplace.

These reasons came from not getting enough exposure and experience in their organisations to not having senior professionals who could assist them in developing their engineering skills. As per Chapter 2, Section 2.6, this is a concern as organisations should be supporting candidate engineers and assisting them with obtaining professional registration with ECSA.

The next contributor to this graph came from candidate engineers unable to progress in their careers due not having obtained professional registration with ECSA. Again, this falls into the same category as engineers not being provided with the necessary experience and training in the organisations they work for to obtain professional registration.

4.6.6. Levels of Responsibility for each ECSA Outcome

Candidate engineers had to rate the levels of responsibility they operate at for each of the 11 ECSA outcomes as per Chapter 2, Table 5. Tables 17-27 below display the responses received for the 11 outcomes, and compares them to the analysis done in Table 16. As per Figure 14, the 173 respondents who selected that they are registered as candidate engineers with ECSA answered this question.

From Table 16, it has already been stated that phases 1, 2 & 5 showed a lower actual response rate than expected and phases 3 & 4 showed a higher actual response rate than expected.

<table>
<thead>
<tr>
<th>ECSA LITERATURE GUIDELINES (Table 5)</th>
<th>EXPECTED RESULTS DERIVED FROM WORK EXPERIENCE (Table 16)</th>
<th>ACTUAL LEVEL OF RESPONSIBILITY (Table 16)</th>
<th>ACTUAL RESPONSE (ECSA Knowledge Area)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ECSA OUTCOME 1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PHASE 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Observation</td>
<td>0-12 months</td>
<td>8%</td>
<td>4%</td>
</tr>
<tr>
<td>2 Assisting</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Participating</td>
<td>12-30 months</td>
<td>22%</td>
<td>34%</td>
</tr>
<tr>
<td>4 Contributing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Performing</td>
<td>30-36+ months</td>
<td>70%</td>
<td>62%</td>
</tr>
</tbody>
</table>

For ECSA Outcome 1, 12% of candidate engineers were actually operating at the levels of observation and assisting. Based on their working experience and their actual levels of responsibility from Table 16 above, only 8% and 4% respectively, were expected to be at these levels.
45% of candidate engineers were actually operating at the levels of participating and contributing. Based on their working experience and their actual levels of responsibility from Table 16 above, only 22% and 34% respectively, were expected to be at these levels.

43% of candidate engineers were actually operating at the level of performing. Based on their working experience and their actual levels of responsibility from Table 16 above, 70% and 62% respectively, were expected to be at these levels.

**Table 18 – ECSA outcome 2**

<table>
<thead>
<tr>
<th>ECSA LITERATURE GUIDELINES (Table 5)</th>
<th>EXPECTED RESULTS DERIVED FROM WORK EXPERIENCE (Table 16)</th>
<th>ACTUAL LEVEL OF RESPONSIBILITY (Table 16)</th>
<th>ACTUAL RESPONSE (ECSA Knowledge Area)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ECSA OUTCOME 2</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PHASE</td>
<td>LEVEL</td>
<td>WORKING EXPERIENCE</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Assisting</td>
<td>12-30 months</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>Contributing</td>
<td>30-36+ months</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For ECSA Outcome 2, 10% of candidate engineers were actually operating at the levels of observation and assisting. Based on their working experience and their actual levels of responsibility from Table 16 above, only 8% and 4% respectively, were expected to be at these levels.

57% of candidate engineers were actually operating at the levels of participating and contributing. Based on their working experience and their actual levels of responsibility from Table 16 above, only 22% and 34% respectively, were expected to be at these levels.

33% of candidate engineers were actually operating at the level of performing. Based on their working experience and their actual levels of responsibility from Table 16 above, 70% and 62% respectively, were expected to be at these levels.
For ECSA Outcome 3, 13% of candidate engineers were actually operating at the levels of observation and assisting. Based on their working experience and their actual levels of responsibility from Table 16 above, only 8% and 4% respectively, were expected to be at these levels.

42% of candidate engineers were actually operating at the levels of participating and contributing. Based on their working experience and their actual levels of responsibility from Table 16 above, only 22% and 34% respectively, were expected to be at these levels.

45% of candidate engineers were actually operating at the level of performing. Based on their working experience and their actual levels of responsibility from Table 16 above, 70% and 62% respectively, were expected to be at these levels.

For ECSA Outcome 4, 11% of candidate engineers were actually operating at the levels of observation and assisting. Based on their working experience and their actual levels of responsibility from Table 16 above, only 8% and 4% respectively, were expected to be at these levels.

46% of candidate engineers were actually operating at the levels of participating and contributing. Based on their working experience and their actual levels of responsibility from Table 16 above, only 22% and 34% respectively, were expected to be at these levels.
43% of candidate engineers were actually operating at the level of performing. Based on their working experience and their actual levels of responsibility from Table 16 above, 70% and 62% respectively, were expected to be at these levels.

Table 21 – ECSA outcome 5

<table>
<thead>
<tr>
<th>ECSA LITERATURE GUIDELINES (Table 5)</th>
<th>EXPECTED RESULTS DERIVED FROM WORK EXPERIENCE (Table 16)</th>
<th>ACTUAL LEVEL OF RESPONSIBILITY (Table 16)</th>
<th>ACTUAL RESPONSE (ECSA Knowledge Area)</th>
</tr>
</thead>
<tbody>
<tr>
<td>To be able to communicate clearly with others in the course of relevant engineering activities.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Observation</td>
<td>0-12 months</td>
<td>8%</td>
<td>4%</td>
</tr>
<tr>
<td>2 Assisting</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Participating</td>
<td>12-30 months</td>
<td>22%</td>
<td>34%</td>
</tr>
<tr>
<td>4 Contributing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Performing</td>
<td>30-36+ months</td>
<td>70%</td>
<td>62%</td>
</tr>
</tbody>
</table>

For ECSA Outcome 5, 5% of candidate engineers were actually operating at the levels of observation and assisting. Based on their working experience and their actual levels of responsibility from Table 16 above, 8% and 4% respectively, were expected to be at these levels.

38% of candidate engineers were actually operating at the levels of participating and contributing. Based on their working experience and their actual levels of responsibility from Table 16 above, only 22% and 34% respectively, were expected to be at these levels.

57% of candidate engineers were actually operating at the level of performing. Based on their working experience and their actual levels of responsibility from Table 16 above, 70% and 62% respectively, were expected to be at these levels.

Table 22 – ECSA outcome 6

<table>
<thead>
<tr>
<th>ECSA LITERATURE GUIDELINES (Table 5)</th>
<th>EXPECTED RESULTS DERIVED FROM WORK EXPERIENCE (Table 16)</th>
<th>ACTUAL LEVEL OF RESPONSIBILITY (Table 16)</th>
<th>ACTUAL RESPONSE (ECSA Knowledge Area)</th>
</tr>
</thead>
<tbody>
<tr>
<td>To be able to recognize and address the reasonably foreseeable cultural, social and the environmental effects of engineering activities.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Observation</td>
<td>0-12 months</td>
<td>8%</td>
<td>4%</td>
</tr>
<tr>
<td>2 Assisting</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Participating</td>
<td>12-30 months</td>
<td>22%</td>
<td>34%</td>
</tr>
<tr>
<td>4 Contributing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Performing</td>
<td>30-36+ months</td>
<td>70%</td>
<td>62%</td>
</tr>
</tbody>
</table>
For ECSA Outcome 6, 8% of candidate engineers were actually operating at the levels of observation and assisting. Based on their working experience and their actual levels of responsibility from Table 16 above, 8% and 4% respectively, were expected to be at these levels.

53% of candidate engineers were actually operating at the levels of participating and contributing. Based on their working experience and their actual levels of responsibility from Table 16 above, only 22% and 34% respectively, were expected to be at these levels.

39% of candidate engineers were actually operating at the level of performing. Based on their working experience and their actual levels of responsibility from Table 16 above, 70% and 62% respectively, were expected to be at these levels.

**Table 23 – ECSA outcome 7**

<table>
<thead>
<tr>
<th>ECSA LITERATURE GUIDELINES (Table 5)</th>
<th>EXPECTED RESULTS DERIVED FROM WORK EXPERIENCE (Table 16)</th>
<th>ACTUAL LEVEL OF RESPONSIBILITY (Table 16)</th>
<th>ACTUAL RESPONSE (ECSA Knowledge Area)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ECSA OUTCOME 7</strong></td>
<td><strong>PHASE</strong></td>
<td><strong>LEVEL</strong></td>
<td><strong>WORKING EXPERIENCE</strong></td>
</tr>
<tr>
<td>To be able to meet all of the legal and the regulatory requirements, as well as protect the health and safety of all persons in the course of relevant engineering activities.</td>
<td>1</td>
<td>Observation</td>
<td>0-12 months</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Assisting</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Participating</td>
<td>12-30 months</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Contributing</td>
<td>30-36+ months</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Performing</td>
<td>30-36+ months</td>
</tr>
</tbody>
</table>

For ECSA Outcome 7, 14% of candidate engineers were actually operating at the levels of observation and assisting. Based on their working experience and their actual levels of responsibility from Table 16 above, only 8% and 4% respectively, were expected to be at these levels.

52% of candidate engineers were actually operating at the levels of participating and contributing. Based on their working experience and their actual levels of responsibility from Table 16 above, only 22% and 34% respectively, were expected to be at these levels.

34% of candidate engineers were actually operating at the level of performing. Based on their working experience and their actual levels of responsibility from Table 16 above, 70% and 62% respectively, were expected to be at these levels.
For ECSA Outcome 8, 6% of candidate engineers were actually operating at the levels of observation and assisting. Based on their working experience and their actual levels of responsibility from Table 16 above, 8% and 4% respectively, were expected to be at these levels.

33% of candidate engineers were actually operating at the levels of participating and contributing. Based on their working experience and their actual levels of responsibility from Table 16 above, only 22% and 34% respectively, were expected to be at these levels.

61% of candidate engineers were actually operating at the level of performing. Based on their working experience and their actual levels of responsibility from Table 16 above, 70% and 62% respectively, were expected to be at these levels.

For ECSA Outcome 9, 6% of candidate engineers were actually operating at the levels of observation and assisting. Based on their working experience and their actual levels of responsibility from Table 16 above, 8% and 4% respectively, were expected to be at these levels.

45% of candidate engineers were actually operating at the levels of participating and contributing. Based on their working experience and their actual levels of responsibility from Table 16 above, only 22% and 34% respectively, were expected to be at these levels.
49% of candidate engineers were actually operating at the level of performing. Based on their working experience and their actual levels of responsibility from Table 16 above, 70% and 62% respectively, were expected to be at these levels.

**Table 26 – ECSA outcome 10**

<table>
<thead>
<tr>
<th>ECSA LITERATURE GUIDELINES (Table 5)</th>
<th>EXPECTED RESULTS</th>
<th>ACTUAL LEVEL</th>
<th>ACTUAL RESPONSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>To be responsible for making decisions on part of or all of engineering activities.</td>
<td>DERIVED FROM WORK EXPERIENCE (Table 16)</td>
<td>OF RESPONSIBILITY (Table 16)</td>
<td>(ECSA Knowledge Area)</td>
</tr>
<tr>
<td>1 Observation 0-12 months</td>
<td>8%</td>
<td>4%</td>
<td>2%</td>
</tr>
<tr>
<td>2 Assisting 12-30 months</td>
<td>22%</td>
<td>34%</td>
<td>9%</td>
</tr>
<tr>
<td>3 Participating 30-36+ months</td>
<td>70%</td>
<td>62%</td>
<td>20%</td>
</tr>
</tbody>
</table>

For ECSA Outcome 10, 11% of candidate engineers were actually operating at the levels of observation and assisting. Based on their working experience and their actual levels of responsibility from Table 16 above, only 8% and 4% respectively, were expected to be at these levels.

51% of candidate engineers were actually operating at the levels of participating and contributing. Based on their working experience and their actual levels of responsibility from Table 16 above, only 22% and 34% respectively, were expected to be at these levels.

38% of candidate engineers were actually operating at the level of performing. Based on their working experience and their actual levels of responsibility from Table 16 above, 70% and 62% respectively, were expected to be at these levels.

**Table 27 – ECSA outcome 11**

<table>
<thead>
<tr>
<th>ECSA LITERATURE GUIDELINES (Table 5)</th>
<th>EXPECTED RESULTS</th>
<th>ACTUAL LEVEL</th>
<th>ACTUAL RESPONSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>To be able to undertake the professional development activities which are sufficient to maintain and extend his or her engineering competence.</td>
<td>DERIVED FROM WORK EXPERIENCE (Table 16)</td>
<td>OF RESPONSIBILITY (Table 16)</td>
<td>(ECSA Knowledge Area)</td>
</tr>
<tr>
<td>1 Observation 0-12 months</td>
<td>8%</td>
<td>4%</td>
<td>3%</td>
</tr>
<tr>
<td>2 Assisting 12-30 months</td>
<td>22%</td>
<td>34%</td>
<td>8%</td>
</tr>
<tr>
<td>3 Participating 30-36+ months</td>
<td>70%</td>
<td>62%</td>
<td>18%</td>
</tr>
<tr>
<td>5 Performing 30-36+ months</td>
<td>70%</td>
<td>62%</td>
<td>29%</td>
</tr>
</tbody>
</table>
For ECSA Outcome 11, 11% of candidate engineers were actually operating at the levels of observation and assisting. Based on their working experience and their actual levels of responsibility from Table 16 above, only 8% and 4% respectively, were expected to be at these levels.

47% of candidate engineers were actually operating at the levels of participating and contributing. Based on their working experience and their actual levels of responsibility from Table 16 above, only 22% and 34% respectively, were expected to be at these levels.

42% of candidate engineers were actually operating at the level of performing. Based on their working experience and their actual levels of responsibility from Table 16 above, 70% and 62% respectively, were expected to be at these levels.

For the responsibility level of performing, i.e. Phase 5, the following can be noted.

As per Chapter 2, Section 2.4, candidate engineers should be able to obtain professional registration once they show that they can operate at the level of performing for each of the ECSA outcomes. For this purpose, the following analysis was done using only the responses received for the level of performing, i.e. Phase 5.

From Tables 17-27 above, the responses for each ECSA outcome at the performing phase were ranked, with the highest values being ranked as Number 1 and the lowest values being ranked as Number 11. This produced Table 28 below.
According to candidate engineers responses received, 62% of candidate engineers operate at an overall level of performing (working without supervision). If this is cross checked with the performing level of each ECSA outcome, it can be seen that the performing levels of each ECSA outcome do not correspond to the overall level of responsibility.

A significant difference (bigger than 20%) between the overall performing level of responsibility and each of the ECSA outcomes for the level of performing is noticeable for:

- ECSA Outcomes 2, 6, 7, 10 & 11.

This shows that the outcomes in which candidate engineer respondents are lacking knowledge is in the development of solutions to engineering problems, the ability to address effects of engineering activities, the
ability to adhere to regulatory requirements, personal attributes such as taking responsibility, making decisions and to undertake professional development to maintain engineering competence.

This question was also evaluated for reliability and internal consistency using the Alpha-Cronbach theory for measuring statistics. This was done using the IBM SPSS Tool. The complete results of this analysis can be seen in Appendix B. For the purposes of providing a reliability analysis the following can be noted.

These results were done using each of the responses received for the 11 ECSA outcomes.

The responses were categorized and rated as follows:

- Observation = 1
- Assisting = 2
- Participating = 3
- Contributing = 4
- Performing = 5

### CASE PROCESSING SUMMARY

<table>
<thead>
<tr>
<th>CASES</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid</td>
<td>173</td>
<td>100</td>
</tr>
<tr>
<td>Excluded</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>173</td>
<td>100</td>
</tr>
</tbody>
</table>

### RELIABILITY STATISTICS

<table>
<thead>
<tr>
<th>CRONBACH’S ALPHA</th>
<th>CRONBACH’S ALPHA BASED ON STANDARDIZED ITEMS</th>
<th>N OF ITEMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.965</td>
<td>0.965</td>
<td>11</td>
</tr>
</tbody>
</table>

From the Reliability Statistics table above, we can see that Cronbach’s alpha is **0.965**, which indicates a very high level of internal consistency for our scale with this question.

### 4.6.7. Chosen Support Programs to obtain Professional Registration

Candidate engineers were thereafter requested to state whether they were a part of any formal development programs to help them prepare for professional registration. These results can be seen in Figure 22 below. As per Figure 14, the 173 respondents who selected that they are registered as candidate engineers with ECSA answered this question. A total of **308** options which were selected from the multi-select box provided in the questionnaire.
The biggest contributor to the development of candidate engineers into professional engineers came from Active mentoring from senior professionals within the organization. This shows that candidate engineers are receiving help and support from senior professionals in their organisations. A major concern came from the fact that 15% (2nd largest contributor) of respondents were not supported by any program to help them achieve professional registration status with ECSA.

### 4.6.8. Candidates Responsible for Development of Graduate Engineers

Candidate engineers were finally requested to state whether they were directly responsible for the development of graduate engineers. Figure 23 below shows the results of the responses received. As per Figure 14, the 173 respondents who selected that they are registered as candidate engineers with ECSA answered this question.
24% of respondents stated that they are currently responsible for the development of graduate engineers in their organisations. 1 of these respondents had between 18-30 months of working experience and was operating at the level of performing with approval of work output (contributing), i.e. not the highest level.

A concern from the data collected above can be raised as to why candidate engineers are currently being allowed to develop graduate engineers when some of them are not operating at the performing level. As per Chapter 2, Section 2.3, candidate engineers should be mentored by senior professionals in the industry. These results indicate that graduate engineers are not being supported by the appropriate professionals in the industry.

This was the end of the questionnaire for respondents who were candidate engineers.

4.7. **Professional Engineer Information**

Respondents who are currently registered as professional engineers were directed from Section 2.1 to Section 4 of the questionnaire. Their responses were specific and only applicable to questions relevant to professional engineers.

4.7.1. **Engineering Related Working Experience**

Professional engineers were requested to state their engineering related work experience since graduation. Figure 24 below shows the responses received. As per Figure 14, the 418 respondents who selected that they are registered as professional engineers with ECSA answered this question.
Only 1% of respondents had very little engineering related working experience constituting of 3-5 years. This was expected as engineers require a minimum of 3 years of engineering experience to obtain professional registration. The balance of 99% of respondents had engineering related working experience greater than 5 years.

Overall there was a good representation of professional engineers who had engineering related experience between 5-10+ years. This would provide information showing whether they obtained professional registration within the required time.

As per the literature reviewed under Chapter 2, Section 2.3, professional engineers should be operating at a level of working without supervision. Further analysis on comparing respondents working experience is done below.

4.7.2. Actual Levels of Responsibility in the Workplace

Professional engineers were then requested to state the levels of responsibility which they operate at in the workplace. Figure 25 below shows the responses received. As per Figure 14, the 418 respondents who selected that they are registered as professional engineers with ECSA answered this question.
The largest group of responses received for this question showed that 92% of respondents were operating at the level of working without supervision (performing). A small number (8%) of respondents were operating at levels below this. With reference to the literature reviewed in Chapter 2, Section 2.3, professional engineers should be operating at a level of working without supervision in the workplace. Based on the responses received for this question, concerns can be raised as to why 8% of respondents were not currently operating at this level.

4.7.3. Opinions on Levels of Responsibility in the Workplace

Professional engineers had to state the levels of responsibility in which they feel they should be operating at in the workplace. Figure 26 below shows the responses received. As per Figure 14, the 418 respondents who selected that they are registered as professional engineers with ECSA answered this question.
The largest group of responses received for this question showed that 95% of respondents felt that they should be 
operating at the level of working without supervision (performing). A total of 5% of respondents felt that they 
should be operating at lower levels of responsibility. As per Chapter 2, Section 2.3, professionally registered 
engineers should operate at the level of performing.

The following is a summary of the total number of 418 professional engineers and the levels of responsibility they 
operate at and feel they should be operating at in the workplace. This is shown in Table 29 below.

Table 29 – Levels professional engineers felt they should be operating at

<table>
<thead>
<tr>
<th>WORK EXPERIENCE</th>
<th>PROFESSIONAL ENGINEER’S OPINIONS ON THE LEVELS THEY SHOULD BE OPERATING AT</th>
<th>A LEVEL BELOW THE LEVEL CURRENTLY OPERATING AT</th>
<th>A LEVEL ABOVE THE LEVEL CURRENTLY OPERATING AT</th>
<th>THE LEVEL THEY CURRENTLY OPERATE AT</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-5 years</td>
<td></td>
<td>-</td>
<td>-</td>
<td>3 (1%)</td>
</tr>
<tr>
<td>5-7 years</td>
<td></td>
<td>1 (0%)</td>
<td>1 (0%)</td>
<td>13 (3%)</td>
</tr>
<tr>
<td>7-10 years</td>
<td></td>
<td>1 (0%)</td>
<td>1 (0%)</td>
<td>21 (5%)</td>
</tr>
<tr>
<td>10+ years</td>
<td></td>
<td>5 (1%)</td>
<td>13 (3%)</td>
<td>359 (86%)</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>7 (2%)</td>
<td>15 (3%)</td>
<td>396 (95%)</td>
</tr>
</tbody>
</table>

The results depicted in Table 29 above raises questions as to why 5% (3% + 2%) of professional engineers, felt that 
they shouldn’t be operating at the level of working without supervision (performing), given that they are 
professional engineers. This also raises the question of whether these engineers are being given the correct 
support mechanisms in the workplace to progress to the next levels of their careers.

From the literature reviewed in Chapter 2, Section 2.3, professional engineers should be operating at a level 
without supervision, i.e. not a level below or above the one they are currently operating at.

4.7.4. ECSA Registration Details

Professional engineers were requested to state how long after initially registering with ECSA as candidate 
engineers, did they obtain professional registration with ECSA. Figure 27 below shows the responses received. As 
per Figure 14, the 418 respondents who selected that they are registered as professional engineers with ECSA 
answered this question.
From the data collected in Figure 27 above it can be seen that 60% of respondents were able to obtain professional registration with ECSA in the time frame of 3-5 years. As per Chapter 2, Section 2.3, this is relative to what ECSA states it should take to obtain professional registration.

From the above it can be gathered that 40% of professional engineers took longer than the required time to obtain professional registration with ECSA. Concerns can be raised regarding why it took these engineers longer than expected to obtain professional registration.

**Table 30 – Time taken to obtain professional registration vs. working experience**

<table>
<thead>
<tr>
<th>WORK EXPERIENCE</th>
<th>TIME TAKEN TO OBTAIN PROFESSIONAL REGISTRATION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3-5 years</td>
</tr>
<tr>
<td>3-5 years</td>
<td>3 (1%)</td>
</tr>
<tr>
<td>5-7 years</td>
<td>9 (2%)</td>
</tr>
<tr>
<td>7-10 years</td>
<td>12 (3%)</td>
</tr>
<tr>
<td>10+ years</td>
<td>225 (54%)</td>
</tr>
<tr>
<td>TOTAL</td>
<td>249 (60%)</td>
</tr>
</tbody>
</table>

From Table 30 above, it can be deduced that 40% of engineers took longer than 3-5 years to obtain professional registration and already had more than 5 years of working experience. There was a total of 36% of professional engineers, who currently had 10+ years of experience and stated that they took longer than the required time to obtain professional registration.

**4.7.5. Chosen Support Programs to obtain Professional Registration**

Professional engineers were requested to state if they were supported by a formal development program to assist them in preparing for professional registration. Figure 28 below shows the responses received. As per Figure 14, the 418 respondents who selected that they are registered as professional engineers with ECSA answered this question. A total of 610 options were selected from the multi-select box provided in the questionnaire.
Whilst many professional engineers stated that they were part of a development program, a total of 112 out of 610 (18%) (3rd largest) respondents stated that they were not supported by any of the development programs mentioned in the questionnaire. The largest contributors to the development of professional engineers came from active mentoring from senior professionals within the organization and watching/shadowing senior engineering professionals in the organization. This showed that senior professionals in the organization played a crucial role in the development of candidate engineers into professional engineers.

4.7.6. **Opinion on the Best Support Programs to obtain Professional Registration**

Following this, the questionnaire requested professional engineers to state what they thought were some of the best methods to obtain professional registration. Figure 29 below shows the responses received. As per Figure 14, the 418 respondents who selected that they are registered as professional engineers with ECSA answered this question. A total of 883 options were selected from the multi-select box provided in the questionnaire.
The biggest trend revealed, was that candidate engineers should make use of active mentoring from senior professionals within the organization to support them in obtaining professional registration status. Given that most of the professional engineers used this method to help them obtain professional registration, this response was expected.

This suggested that professional engineers supported the belief that the best way to develop graduate engineers into professional engineers is through the help of senior professionals in their working environments.

With these suggestions coming from already registered professional engineers who have the experience and knowledge of what it takes to obtain professional registration, it can be deduced that these responses represent the current thoughts of professional engineers in South Africa.

4.7.7. Professionals Responsible for Development of Graduate Engineers

Professional engineers were finally requested to state if they were directly responsible for the development of graduate engineers in their organisations. Figure 30 below shows the responses received. As per Figure 14, the 418 respondents who selected that they are registered as professional engineers with ECSA answered this question.
55% of respondents stated that they are directly responsible for the development of graduate engineers. This was fitting as professional engineers should be operating at a level whereby they do not require supervision to operate effectively in the workplace. This would put them in a good position to mentor younger engineers in achieving their own professional registration status.

A concern established from the responses received above was that 6% of respondents who were directly responsible for the development of graduates were not operating at the highest level of responsibility. As per Chapter 2, Section 2.3, professional engineers should be operating at the highest level due to their registration status with ECSA. It is concerning that although they are not operating at the highest level; they are being allowed to develop graduate engineers.

It should also be noted that the balance of 45% of professional engineers who are not responsible for the direct development of graduate engineers in their organisations could do so if they are operating at the highest level of responsibility in the workplace.

This was the end of the questionnaire for respondents who were professional engineers.

4.8. Unregistered Engineer Information

Respondents who are currently not registered with ECSA were directed from Section 2.1 to Section 5 of the questionnaire. Their responses were specific and only applicable to questions relevant to engineers who were not registered with ECSA.

4.8.1. Engineering Related Working Experience

Unregistered engineers were requested to state their engineering related work experience since graduation. Figure 31 below shows the responses received. As per Figure 12, the 179 respondents who selected that they are not registered with ECSA answered this question.
Just more than a third of unregistered engineers who had responded to the survey had 10+ years of engineering related working experience. Taking into account the literature reviewed in Chapter 2, Section 2.3, engineers should be able to register as professional engineers after 36 months of working as a candidate engineer in the workplace.

With that said, at least, 78% of respondents who are not registered with ECSA could have been able to obtain professional registration with ECSA. Table 31 below, shows this comparison to literature.

### Table 31 – Unregistered engineers working experience vs. literature guidelines

<table>
<thead>
<tr>
<th>WORKING EXPERIENCE</th>
<th>21 - 29 YEARS OLD</th>
<th>30 - 39 YEARS OLD</th>
<th>40 - 49 YEARS OLD</th>
<th>50 - 59 YEARS OLD</th>
<th>60 YEARS OLD AND OLDER</th>
<th>LITERATURE GUIDELINES</th>
<th>ACTUAL RESULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 3 years</td>
<td>37 (21%)</td>
<td>1 (0.5%)</td>
<td>-</td>
<td>1 (0.5%)</td>
<td>-</td>
<td>Candidate Engineer</td>
<td>Unregistered Engineers</td>
</tr>
<tr>
<td>3 - 5 years</td>
<td>26 (14%)</td>
<td>11 (6%)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Professional Engineer</td>
<td></td>
</tr>
<tr>
<td>5 - 7 years</td>
<td>4 (2%)</td>
<td>11 (6%)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 - 10 years</td>
<td>2 (1%)</td>
<td>23 (13%)</td>
<td>2 (0.5%)</td>
<td>1 (0.5%)</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10+ years</td>
<td>1 (0.5%)</td>
<td>13 (7%)</td>
<td>17 (9%)</td>
<td>17 (9%)</td>
<td>12 (7%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTALS</td>
<td>70 (39%)</td>
<td>59 (33%)</td>
<td>19 (10%)</td>
<td>19 (11%)</td>
<td>12 (7%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

From Table 31 above it is clear that 78% of the 179 unregistered engineers who are in the current industry, had 3+ years of working experience, and could have obtained professional registration with ECSA.

### 4.8.2. Actual Levels of Responsibility in the Workplace

Respondents were then requested to state the levels of responsibility they operate at in the workplace. Figure 32 below shows the responses received. As per Figure 12, the 179 respondents who selected that they are not registered with ECSA answered this question.
The largest group of responses received for this question showed that 53% of respondents were operating at the level of working without supervision (performing). There was a good distribution amongst respondents who were operating between the levels of participating, contributing and performing. The distribution consisted of a gradual increase in levels from participating to performing.

With reference to the literature reviewed in Chapter 2, Section 2.3, a candidate engineer should be operating at specific levels in the workplace, depending on their engineering related working experience. Further analysis on this was done and is shown below.

**4.8.3. Opinions on Levels of Responsibility in the Workplace**

Unregistered engineers were requested to state the levels of responsibility they felt they should be operating at in the workplace. Figure 33 below shows the responses received. As per Figure 12, the 179 respondents who selected that they are not registered with ECSA answered this question.
The largest group of responses received for this question showed that 62% of respondents felt that they should be operating at the level of working without supervision (performing). This noted concern as a number of unregistered engineers stated that they should be operating at different levels of responsibility compared to where they currently work. Questions can be asked as to why these unregistered engineers are unable to work at the levels of responsibility they feel they could be operating at.

The following is a summary of the total number of 179 unregistered engineers and the levels of responsibility they operate at and feel they should be operating at in the workplace. This is shown in Table 32 below.

The results depicted in Table 32 above raise concerns as to why 26% (19% + 7%) of unregistered engineers feel that they should be operating at different levels in the workplace. This also raises the question of whether these engineers are being given the correct support mechanisms in the workplace, to progress to the next levels of their careers.

As per Table 5, Chapter 2 above, ECSA states that candidate engineers should undergo a specific training period, especially during the early years of their careers. Based on this, the following analysis was done.
Table 33 below was compiled based on respondents who only had the graduate B.Sc./B.Eng. Engineering and Honours degrees. This was 101 out of 179 (56%) respondents.

Respondents with Masters and Doctoral Engineering degrees were excluded from the comparison below, as they could have obtained these qualifications after already working in the industry.

It was assumed that graduate engineers will begin their careers in the year following their graduation, and from this the following can be derived.

Table 33 – Expected vs. actual operating levels in the workplace

<table>
<thead>
<tr>
<th>PHASES OF DEVELOPMENT PERIOD OF A GRADUATE ENGINEER FROM LITERATURE</th>
<th>OBSERVING</th>
<th>PERFORMING UNDER CLOSE SUPERVISION</th>
<th>PERFORMING UNDER LIMITED SUPERVISION</th>
<th>PERFORMING WITH APPROVAL OF WORK OUTPUT</th>
<th>WORKING RESPONSIBLY WITHOUT SUPERVISION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>6 – 12 Months</td>
<td>12 – 30 Months</td>
<td>30 – 36+ Months</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**RESPONDENTS EXPECTED LEVELS OF RESPONSIBILITY DERIVED FROM DATES OF GRADUATION**

| 12 (12%) | 6 (6%) | 83 (82%) |

**RESPONDENTS ACTUAL LEVELS OF RESPONSIBILITY BASED ON RESPONDENTS ACTUAL SELECTION**

| 6 (6%) | 45 (44%) | 50 (50%) |

**RESPONDENTS OPINIONS ON LEVELS OF RESPONSIBILITY BASED ON RESPONDENTS ACTUAL SELECTION**

| 3 (3%) | 38 (38%) | 60 (59%) |

Table 33 above shows the percentage of unregistered engineers and the levels of responsibility they should be operating at in the workplace, based on their dates of graduation.

12% of respondents were expected to be operating at the levels of observing and performing under close supervision. Only 6% of respondents were actually operating at these levels and only 3% of respondents felt that they should be operating at these levels.

6% of respondents were expected to be operating at the levels of performing under limited supervision and performing with approval of work output. 44% of respondents were actually operating at these levels and 38% of respondents felt that they should be operating at these levels.

82% of respondents were expected to be operating at the level of operating responsibly without supervision. Only 50% of respondents were actually operating at this level and only 59% of respondents felt that they should be operating at this level.
It can be stated that phases 1, 2 & 5 showed a lower actual response rate received than what was expected and phases 3 & 4 showed a higher actual response rate than expected.

A concern from this can be raised as to why so many unregistered engineers feel that they do not have the confidence to operate at the level of working responsibly without supervision.

4.8.4. Reasons for Not Operating At the Correct Levels

Unregistered engineers had to state what is preventing them from operating at the levels of responsibility they felt they should be operating. The results of this question were summarized into groups of years and can be seen in Figure 34 below. As per Figure 12, the 179 respondents who selected that they are not registered with ECSA answered this question.

![Figure 33 – Summary of reasons unregistered engineers were not operating at their preferred levels](image)

Half of unregistered engineer respondents chose to leave this option blank and state that a lot of them were operating at the levels they felt they should be at in the workplace. The next biggest contributor to Figure 34 above came from unregistered engineers who were not being developed effectively because of reasons occurring in the workplace.

These reasons came from not getting enough exposure and experience in their organisations to not having senior professionals who could assist them in developing their engineering skills. As per Chapter 2, Section 2.6, this is a concern as organisations should be supporting engineers and assisting them with obtaining professional registration with ECSA.
The next contributor to this graph came from unregistered engineers unable to progress in their careers due to not having obtained professional registration with ECSA. Again, this falls into the same category as engineers not being provided with the necessary experience and training in the organisations they work for to obtain professional registration.

4.8.5. Levels of Responsibility for each ECSA Outcome

Unregistered engineers then had to rate the levels of responsibility they operate at for each of the 11 ECSA outcomes as per Chapter 2, Table 5. Tables 34-44 below, show the response received for each of the 11 outcomes and compares them to the analysis done in Table 33. As per Figure 12, the 179 respondents who selected that they are not registered with ECSA answered this question.

From Table 33, it has already been stated that phases 1, 2 & 5 reflect a lower actual response rate than expected and phases 3 & 4 reflect a higher actual response rate than expected.

### Table 34 – ECSA outcome 1

<table>
<thead>
<tr>
<th>ECSA LITERATURE GUIDELINES (Table 5)</th>
<th>EXPECTED RESULTS DERIVED FROM DATES OF GRAD. (Table 33)</th>
<th>ACTUAL LEVEL OF RESPONSIBILITY (Table 33)</th>
<th>ACTUAL RESPONSE (ECSA Knowledge Area)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSA OUTCOME 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>To be able to define, investigate and analyse engineering problems.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Observation</td>
<td>0-12 months</td>
<td>12%</td>
<td>6%</td>
</tr>
<tr>
<td>2 Assisting</td>
<td>12-30 months</td>
<td>6%</td>
<td>4%</td>
</tr>
<tr>
<td>3 Participating</td>
<td>30-36+ months</td>
<td>82%</td>
<td>50%</td>
</tr>
<tr>
<td>4 Contributing</td>
<td>30-36+ months</td>
<td>50%</td>
<td>54%</td>
</tr>
<tr>
<td>5 Performing</td>
<td>30-36+ months</td>
<td>82%</td>
<td>50%</td>
</tr>
</tbody>
</table>

For ECSA Outcome 1, 11% of unregistered engineers were actually operating at the levels of observation and assisting. Based on their dates of graduation and their actual levels of responsibility from Table 33 above, only 12% and 6% respectively, were expected to be at these levels.

35% of unregistered engineers were actually operating at the levels of participating and contributing. Based on their dates of graduation and their actual levels of responsibility from Table 33 above, 6% and 44% respectively, were expected to be at these levels.

54% of unregistered engineers were actually operating at the level of performing. Based on their dates of graduation and their actual levels of responsibility from Table 33 above, 82% and 50% respectively, were expected to be at these levels.
For ECSA Outcome 2, 12% of unregistered engineers were actually operating at the levels of observation and assisting. Based on their dates of graduation and their actual levels of responsibility from Table 33 above, only 12% and 6% respectively, were expected to be at these levels.

47% of unregistered engineers were actually operating at the levels of participating and contributing. Based on their dates of graduation and their actual levels of responsibility from Table 33 above, 6% and 44% respectively, were expected to be at these levels.

41% of unregistered engineers were actually operating at the level of performing. Based on their dates of graduation and their actual levels of responsibility from Table 33 above, 82% and 50% respectively, were expected to be at these levels.

For ECSA Outcome 3, 12% of unregistered engineers were actually operating at the levels of observation and assisting. Based on their dates of graduation and their actual levels of responsibility from Table 33 above, only 12% and 6% respectively, were expected to be at these levels.

43% of unregistered engineers were actually operating at the levels of participating and contributing. Based on their dates of graduation and their actual levels of responsibility from Table 33 above, 6% and 44% respectively, were expected to be at these levels.
45% of unregistered engineers were actually operating at the level of performing. Based on their dates of graduation and their actual levels of responsibility from Table 33 above, 82% and 50% respectively, were expected to be at these levels.

**Table 37 – ECSA outcome 4**

<table>
<thead>
<tr>
<th>ECSA OUTCOME 4</th>
<th>PHASE</th>
<th>LEVEL</th>
<th>WORKING EXPERIENCE</th>
<th>EXPECTED RESULTS DERIVED FROM DATES OF GRAD. (Table 33)</th>
<th>ACTUAL LEVEL OF RESPONSIBILITY (Table 33)</th>
<th>ACTUAL RESPONSE (ECSA Knowledge Area)</th>
</tr>
</thead>
<tbody>
<tr>
<td>To be able to manage a part of or all of one or more engineering activities.</td>
<td>1</td>
<td>Observation</td>
<td>0-12 months</td>
<td>12%</td>
<td>6%</td>
<td>4%</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Assisting</td>
<td>12-30 months</td>
<td>6%</td>
<td>44%</td>
<td>7%</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Participating</td>
<td>30-36+ months</td>
<td>82%</td>
<td>50%</td>
<td>11%</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Contributing</td>
<td>30-36+ months</td>
<td>44%</td>
<td>50%</td>
<td>24%</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Performing</td>
<td>30-36+ months</td>
<td>82%</td>
<td>50%</td>
<td>54%</td>
</tr>
</tbody>
</table>

For ECSA Outcome 4, 11% of unregistered engineers were actually operating at the levels of observation and assisting. Based on their dates of graduation and their actual levels of responsibility from Table 33 above, only 12% and 6% respectively, were expected to be at these levels.

35% of unregistered engineers were actually operating at the levels of participating and contributing. Based on their dates of graduation and their actual levels of responsibility from Table 33 above, 6% and 44% respectively, were expected to be at these levels.

54% of unregistered engineers were actually operating at the level of performing. Based on their dates of graduation and their actual levels of responsibility from Table 33 above, 82% and 50% respectively, were expected to be at these levels.

**Table 38 – ECSA outcome 5**

<table>
<thead>
<tr>
<th>ECSA OUTCOME 5</th>
<th>PHASE</th>
<th>LEVEL</th>
<th>WORKING EXPERIENCE</th>
<th>EXPECTED RESULTS DERIVED FROM DATES OF GRAD. (Table 33)</th>
<th>ACTUAL LEVEL OF RESPONSIBILITY (Table 33)</th>
<th>ACTUAL RESPONSE (ECSA Knowledge Area)</th>
</tr>
</thead>
<tbody>
<tr>
<td>To be able to communicate clearly with others in the course of relevant engineering activities.</td>
<td>1</td>
<td>Observation</td>
<td>0-12 months</td>
<td>12%</td>
<td>6%</td>
<td>3%</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Assisting</td>
<td>12-30 months</td>
<td>6%</td>
<td>44%</td>
<td>6%</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Participating</td>
<td>30-36+ months</td>
<td>82%</td>
<td>50%</td>
<td>8%</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Contributing</td>
<td>30-36+ months</td>
<td>82%</td>
<td>50%</td>
<td>19%</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Performing</td>
<td>30-36+ months</td>
<td>82%</td>
<td>50%</td>
<td>64%</td>
</tr>
</tbody>
</table>

For ECSA Outcome 5, 9% of unregistered engineers were actually operating at the levels of observation and assisting. Based on their dates of graduation and their actual levels of responsibility from Table 33 above, only 12% and 6% respectively, were expected to be at these levels.
27% of unregistered engineers were actually operating at the levels of participating and contributing. Based on their dates of graduation and their actual levels of responsibility from Table 33 above, 6% and 44% respectively, were expected to be at these levels.

64% of unregistered engineers were actually operating at the level of performing. Based on their dates of graduation and their actual levels of responsibility from Table 33 above, 82% and 50% respectively, were expected to be at these levels.

### Table 39 – ECSA outcome 6

<table>
<thead>
<tr>
<th>ECSA LITERATURE GUIDELINES (Table 5)</th>
<th>EXPECTED RESULTS DERIVED FROM DATES OF GRAD. (Table 33)</th>
<th>ACTUAL LEVEL OF RESPONSIBILITY (Table 33)</th>
<th>ACTUAL RESPONSE (ECSA Knowledge Area)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ECSA OUTCOME 6</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Observation</td>
<td>12%</td>
<td>6%</td>
<td>5%</td>
</tr>
<tr>
<td>2 Assisting</td>
<td></td>
<td></td>
<td>9%</td>
</tr>
<tr>
<td>3 Participating</td>
<td>6%</td>
<td>44%</td>
<td>11%</td>
</tr>
<tr>
<td>4 Contributing</td>
<td>12-30 months</td>
<td></td>
<td>31%</td>
</tr>
<tr>
<td>5 Performing</td>
<td>30-36+ months</td>
<td>82%</td>
<td>44%</td>
</tr>
</tbody>
</table>

For ECSA Outcome 6, 14% of unregistered engineers were actually operating at the levels of observation and assisting. Based on their dates of graduation and their actual levels of responsibility from Table 33 above, only 12% and 6% respectively, were expected to be at these levels.

42% of unregistered engineers were actually operating at the levels of participating and contributing. Based on their dates of graduation and their actual levels of responsibility from Table 33 above, 6% and 44% respectively, were expected to be at these levels.

44% of unregistered engineers were actually operating at the level of performing. Based on their dates of graduation and their actual levels of responsibility from Table 33 above, 82% and 50% respectively, were expected to be at these levels.
For ECSA Outcome 7, 16% of unregistered engineers were actually operating at the levels of observation and assisting. Based on their dates of graduation and their actual levels of responsibility from Table 33 above, only 12% and 6% respectively, were expected to be at these levels.

42% of unregistered engineers were actually operating at the levels of participating and contributing. Based on their dates of graduation and their actual levels of responsibility from Table 33 above, 6% and 44% respectively, were expected to be at these levels.

42% of unregistered engineers were actually operating at the level of performing. Based on their dates of graduation and their actual levels of responsibility from Table 33 above, 82% and 50% respectively, were expected to be at these levels.

For ECSA Outcome 8, 8% of unregistered engineers were actually operating at the levels of observation and assisting. Based on their dates of graduation and their actual levels of responsibility from Table 33 above, only 12% and 6% respectively, were expected to be at these levels.
26% of unregistered engineers were actually operating at the levels of participating and contributing. Based on their dates of graduation and their actual levels of responsibility from Table 33 above, 6% and 44% respectively, were expected to be at these levels.

66% of unregistered engineers were actually operating at the level of performing. Based on their dates of graduation and their actual levels of responsibility from Table 33 above, 82% and 50% respectively, were expected to be at these levels.

**Table 42 – ECSA outcome 9**

<table>
<thead>
<tr>
<th>ECSA OUTCOME 9</th>
<th>PHASE</th>
<th>LEVEL</th>
<th>WORKING EXPERIENCE</th>
<th>EXPECTED RESULTS DERIVED FROM DATES OF GRAD. (Table 33)</th>
<th>ACTUAL LEVEL OF RESPONSIBILITY (Table 33)</th>
<th>ACTUAL RESPONSE (ECSA Knowledge Area)</th>
</tr>
</thead>
<tbody>
<tr>
<td>To be able to exercise sound judgment in the course of engineering activities.</td>
<td>1</td>
<td>Observation</td>
<td>0-12 months</td>
<td>12%</td>
<td>6%</td>
<td>3%</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Assisting</td>
<td></td>
<td>6%</td>
<td>44%</td>
<td>7%</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Participating</td>
<td>12-30 months</td>
<td>6%</td>
<td>44%</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Contributing</td>
<td></td>
<td>82%</td>
<td>50%</td>
<td>24%</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Performing</td>
<td>30-36+ months</td>
<td>82%</td>
<td>50%</td>
<td>56%</td>
</tr>
</tbody>
</table>

For ECSA Outcome 9, 10% of unregistered engineers were actually operating at the levels of observation and assisting. Based on their dates of graduation and their actual levels of responsibility from Table 33 above, only 12% and 6% respectively, were expected to be at these levels.

34% of unregistered engineers were actually operating at the levels of participating and contributing. Based on their dates of graduation and their actual levels of responsibility from Table 33 above, 6% and 44% respectively, were expected to be at these levels.

56% of unregistered engineers were actually operating at the level of performing. Based on their dates of graduation and their actual levels of responsibility from Table 33 above, 82% and 50% respectively, were expected to be at these levels.

**Table 43 – ECSA outcome 10**

<table>
<thead>
<tr>
<th>ECSA OUTCOME 10</th>
<th>PHASE</th>
<th>LEVEL</th>
<th>WORKING EXPERIENCE</th>
<th>EXPECTED RESULTS DERIVED FROM DATES OF GRAD. (Table 33)</th>
<th>ACTUAL LEVEL OF RESPONSIBILITY (Table 33)</th>
<th>ACTUAL RESPONSE (ECSA Knowledge Area)</th>
</tr>
</thead>
<tbody>
<tr>
<td>To be responsible for making decisions on part of or all of engineering activities.</td>
<td>1</td>
<td>Observation</td>
<td>0-12 months</td>
<td>12%</td>
<td>6%</td>
<td>3%</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Assisting</td>
<td></td>
<td>6%</td>
<td>44%</td>
<td>8%</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Participating</td>
<td>12-30 months</td>
<td>6%</td>
<td>44%</td>
<td>12%</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Contributing</td>
<td></td>
<td>82%</td>
<td>50%</td>
<td>30%</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Performing</td>
<td>30-36+ months</td>
<td>82%</td>
<td>50%</td>
<td>47%</td>
</tr>
</tbody>
</table>
For ECSA Outcome 10, 11% of unregistered engineers were actually operating at the levels of observation and assisting. Based on their dates of graduation and their actual levels of responsibility from Table 33 above, only 12% and 6% respectively, were expected to be at these levels.

42% of unregistered engineers were actually operating at the levels of participating and contributing. Based on their dates of graduation and their actual levels of responsibility from Table 33 above, 6% and 44% respectively, were expected to be at these levels.

47% of unregistered engineers were actually operating at the level of performing. Based on their dates of graduation and their actual levels of responsibility from Table 33 above, 82% and 50% respectively, were expected to be at these levels.

**Table 44 – ECSA outcome 11**

<table>
<thead>
<tr>
<th>ECSA LITERATURE GUIDELINES (Table 5)</th>
<th>EXPECTED RESULTS DERIVED FROM DATES OF GRAD. (Table 33)</th>
<th>ACTUAL LEVEL OF RESPONSIBILITY (Table 33)</th>
<th>ACTUAL RESPONSE (ECSA Knowledge Area)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSA OUTCOME 11</td>
<td>PHASE</td>
<td>LEVEL</td>
<td>WORKING EXPERIENCE</td>
</tr>
<tr>
<td>1</td>
<td>Observation</td>
<td>0-12 months</td>
<td>12%</td>
</tr>
<tr>
<td>2</td>
<td>Assisting</td>
<td>12-30 months</td>
<td>6%</td>
</tr>
<tr>
<td>3</td>
<td>Participating</td>
<td>12-30 months</td>
<td>6%</td>
</tr>
<tr>
<td>4</td>
<td>Contributing</td>
<td>30-36+ months</td>
<td>82%</td>
</tr>
</tbody>
</table>

For ECSA Outcome 11, 12% of unregistered engineers were actually operating at the levels of observation and assisting. Based on their dates of graduation and their actual levels of responsibility from Table 33 above, only 12% and 6% respectively, were expected to be at these levels.

37% of unregistered engineers were actually operating at the levels of participating and contributing. Based on their dates of graduation and their actual levels of responsibility from Table 33 above, 6% and 44% respectively, were expected to be at these levels.

51% of unregistered engineers were actually operating at the level of performing. Based on their dates of graduation and their actual levels of responsibility from Table 33 above, 82% and 50% respectively, were expected to be at these levels.

For the responsibility level of performing, i.e. Phase 5, the following can be noted.
As per Chapter 2, Section 2.3, candidate engineers should be able to obtain professional registration, once they show that they can work at the level of performing for each of the ECSA outcomes. For this purpose, the following analysis was done using only the responses received for the level of performing, i.e. Phase 5.

From Tables 34-44 above, the responses for each ECSA outcome at the performing level were ranked, with the highest values being ranked as Number 1 and the lowest values being ranked as Number 11. This produced Table 45 below.

Table 45 – ECSA outcomes and rankings

<table>
<thead>
<tr>
<th>ECSA OUTCOMES</th>
<th>RESEARCH RESULTS FOR PERFORMING LEVEL (Phase 5)</th>
<th>DIFFERENCE FROM OVERALL LEVEL OF RESPONSIBILITY</th>
<th>RANK (No.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACTUAL LEVEL OF RESPONSIBILITY (Table 33)</td>
<td>ACTUAL RESPONSE (Tables 34-44)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>To be able to define, investigate and analyse engineering problems.</td>
<td>54%</td>
<td>-4%</td>
<td>4</td>
</tr>
<tr>
<td>To be able to design and/or develop solutions to engineering problems.</td>
<td>41%</td>
<td>9%</td>
<td>11</td>
</tr>
<tr>
<td>To be able to comprehend as well as apply knowledge; principles, specialist knowledge, jurisdictional and local knowledge.</td>
<td>45%</td>
<td>5%</td>
<td>8</td>
</tr>
<tr>
<td>To be able to manage a part of or all of one or more engineering activities.</td>
<td>54%</td>
<td>-4%</td>
<td>4</td>
</tr>
<tr>
<td>To be able to communicate clearly with others in the course of relevant engineering activities.</td>
<td>64%</td>
<td>-14%</td>
<td>2</td>
</tr>
<tr>
<td>To be able to recognize and address the reasonably foreseeable cultural, social and the environmental effects of engineering activities.</td>
<td>44%</td>
<td>6%</td>
<td>9</td>
</tr>
<tr>
<td>To be able to meet all of the legal and the regulatory requirements, as well as protect the health and safety of all persons in the course of relevant engineering activities.</td>
<td>50%</td>
<td>8%</td>
<td>10</td>
</tr>
<tr>
<td>To be able to conduct engineering activities ethically.</td>
<td>66%</td>
<td>-16%</td>
<td>1</td>
</tr>
<tr>
<td>To be able to exercise sound judgement in the course of engineering activities.</td>
<td>56%</td>
<td>-6%</td>
<td>3</td>
</tr>
<tr>
<td>To be responsible for making decisions on part of or all of engineering activities.</td>
<td>47%</td>
<td>3%</td>
<td>7</td>
</tr>
<tr>
<td>To be able to undertake the professional development activities which are sufficient to maintain and extend his or her engineering competence.</td>
<td>51%</td>
<td>-1%</td>
<td>6</td>
</tr>
</tbody>
</table>

According to the responses received, 50% of unregistered engineers operate at an overall level of performing (working without supervision). If this is cross checked with the performing level of each ECSA outcome, it can be seen that the performing levels of each ECSA outcome does not correspond to the overall level of responsibility.
A significant difference (bigger than 5%) between the overall performing level of responsibility and each of the ECSA outcomes for the level of performing is noticeable for:

- ECSA Outcomes 2, 3, 6 & 7.

This shows that the outcomes in which unregistered engineer respondents are lacking knowledge is in the development of solutions to engineering problems, the ability to comprehend and apply knowledge, the ability to address effects of engineering activities and the ability to adhere to regulatory requirements.

This question was also evaluated for reliability and internal consistency using the Alpha-Cronbach theory for measuring statistics. This was done using the IBM SPSS Tool. The complete results of this analysis can be seen in Appendix C. For the purposes of providing a reliability analysis the following can be noted.

These results were done using each of the responses received for each of the 11 ECSA outcomes.

The responses were categorized and rated as follows:

- Observation = 1
- Assisting = 2
- Participating = 3
- Contributing = 4
- Performing = 5

**CASE PROCESSING SUMMARY**

<table>
<thead>
<tr>
<th>CASES</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid</td>
<td>179</td>
<td>100</td>
</tr>
<tr>
<td>Excluded</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>179</td>
<td>100</td>
</tr>
</tbody>
</table>

**RELIABILITY STATISTICS**

<table>
<thead>
<tr>
<th>CRONBACH’S ALPHA</th>
<th>CRONBACH’S ALPHA BASED ON STANDARDIZED ITEMS</th>
<th>N OF ITEMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.970</td>
<td>0.970</td>
<td>11</td>
</tr>
</tbody>
</table>

From the Reliability Statistics table above, we can see that Cronbach’s alpha is **0.970**, which indicates a very high level of internal consistency for our scale with this question.

4.8.6. **Chosen Support Programs to obtain Professional Registration**

Unregistered engineers were requested to state which formal development program they would consider to assist in preparing themselves for professional registration. Figure 36 below shows the responses received. As per Figure
12, the 179 respondents who selected that they are not registered with ECSA answered this question. A total of 283 options which were selected from the multi-select box provided in the questionnaire.

**OPTIONS WHICH UNREGISTERED ENGINEERS WOULD CONSIDER TO ACCELERATE THEIR PROFESSIONAL REGISTRATION**

<table>
<thead>
<tr>
<th>Option</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>No suggestion</td>
<td>20</td>
<td>7%</td>
</tr>
<tr>
<td>Industry training and development as per professional body requirements as part of the engineering qualification.</td>
<td>45</td>
<td>16%</td>
</tr>
<tr>
<td>In-house mentorship for graduates starting their careers through the use of previous graduate engineers</td>
<td>40</td>
<td>14%</td>
</tr>
<tr>
<td>In-house Graduate development programs</td>
<td>34</td>
<td>12%</td>
</tr>
<tr>
<td>Watch/shadow senior engineering professionals in the organization</td>
<td>25</td>
<td>9%</td>
</tr>
<tr>
<td>Active mentoring from senior professionals within the organization</td>
<td>72</td>
<td>25%</td>
</tr>
<tr>
<td>Private mentorship for graduates through the professional body such as the ECSA candidacy program</td>
<td>47</td>
<td>17%</td>
</tr>
</tbody>
</table>

*Figure 34 – Options which unregistered engineers would consider to accelerate their professional registration*

The biggest contributor to the options on the potential development of unregistered engineers into professional engineers could come from active mentoring from senior professional within the organization. This shows that unregistered engineers would consider receiving help and support from senior professionals in their organisations.

**4.8.7. Unregistered Engineers Responsible for Development of Graduate Engineers**

The questionnaire finally requested unregistered engineers to state if they were directly responsible for the development of graduate engineers in their organisations. Figure 37 below shows the responses received. As per Figure 12, the 179 respondents who selected that they are not registered with ECSA answered this question.
33% of respondents stated that they are currently responsible for the development of graduate engineers in their organisations. 14 of these respondents were not operating at the highest level of working without supervision (performing).

A concern from the data collected above can be raised as to why some unregistered engineers are currently being allowed to develop graduate engineers when they are not operating at the highest level. As per Chapter 2, Section 2.3, candidate engineers should be mentored by senior professionals in the industry and this shows that graduate engineers are not being supported by the appropriate professionals in the industry.

This was the end of the questionnaire for the unregistered engineers.

### 4.9. Results Summary

A total of 811 respondents completed the survey, of which 78% of respondents were registered with ECSA. The trend with regards to registration with ECSA suggest that engineers do register with ECSA, however engineers from the younger age groups showed the most number of non-registrations with ECSA.

Table 46 below shows the main points revealed in the analysis concluded.
### Table 46 – Summary of results for engineers

<table>
<thead>
<tr>
<th>TREND CATEGORY</th>
<th>CANDIDATE ENGINEERS</th>
<th>PROFESSIONAL ENGINEERS</th>
<th>UNREGISTERED ENGINEERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering related working experience</td>
<td>Largely registered with ECSA, but did not obtain professional registration in the suggested 3 year time period.</td>
<td>99% had more than 5 years of engineering related working experience.</td>
<td>Distributed between 0-3 years and 10+ years of working experience.</td>
</tr>
<tr>
<td>Time taken to obtain professional registration with ECSA</td>
<td>99% had more than 5 years of engineering related working experience.</td>
<td>40% took longer than 3-5 years to obtain professional registration with ECSA.</td>
<td></td>
</tr>
<tr>
<td>Estimated time to obtain professional registration</td>
<td>Majority estimated that they would take longer than 3 years to obtain professional registration.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall levels of responsibility in the workplace</td>
<td>Not always operating at the correct overall levels of responsibility.</td>
<td>Majority are operating at the expected level of responsibility in the workplace.</td>
<td>Not always operating at the correct levels of responsibility in the workplace when compared to their expected levels of responsibility.</td>
</tr>
<tr>
<td>Opinions on levels of responsibility in the workplace</td>
<td>Did not have the confidence to operate at the correct overall levels of responsibility in the workplace when compared to their expected levels of responsibility.</td>
<td>Majority had the confidence to operate at the correct overall levels of responsibility in the workplace when compared to their expected levels of responsibility.</td>
<td>Did not have the confidence to operate at the correct overall levels of responsibility in the workplace when compared to their expected levels of responsibility.</td>
</tr>
<tr>
<td>Levels of responsibility for each ECSA outcome</td>
<td>The performing level of responsibility for each of the ECSA outcomes showed that they were not performing as expected.</td>
<td>The performing level of responsibility for each of the ECSA outcomes showed that they were not performing as expected.</td>
<td></td>
</tr>
<tr>
<td>Chosen support programs to obtain professional registration</td>
<td>Many were receiving active mentoring from senior professionals, to assist them in obtaining professional registration.</td>
<td>Many received and recommended active mentoring from senior professionals, to assist them in obtaining professional registration.</td>
<td>Many would consider receiving active mentoring from senior professionals, to assist them in obtaining professional registration.</td>
</tr>
</tbody>
</table>

Candidate engineers showed that there is a lack of knowledge at the performing level of responsibility for the following ECSA outcomes:

- The development of solutions to engineering problems.
- The ability to address the effects of engineering activities.
- The ability to adhere to regulatory requirements.
- Personal attributes such as taking responsibility and making decisions.
- Undertaking professional development to maintain engineering competence.
Unregistered engineers showed that there is a lack of knowledge at the performing level of responsibility for the following ECSA outcomes:

- The development of solutions to engineering problems.
- The ability to comprehend and apply knowledge.
- The ability to address the effects of engineering activities.
- The ability to adhere to regulatory requirements.

Chapter 5 below provides the conclusions to the research conducted.
5. **CHAPTER 5: Conclusions**

This chapter reviews whether the research had achieved its objectives. The findings of the research are concluded and recommendations are provided.

It must be remembered that due to the low number of respondents from the survey in comparison with the number of engineers in South Africa, these results should not be generalized. For the purposes of determining trends in South Africa regarding engineers, this was assumed to be sufficient. The results in Chapter 4 above as well as the conclusions stated in this chapter provide the information which can be taken away from the research conducted.

5.1. **Introduction**

The main objective of the research was to ultimately provide the current professional registration trends of engineers in South Africa for graduate engineers to be aware of. This would assist them in being able to professionally develop their skills, between the times of entering the labour market as a graduate engineer, to successfully registering as a professional engineer.

Research results identified the trends in South Africa regarding ECSA registered candidate engineers, professional engineers and engineers not registered with ECSA. It revealed that there was a direct relationship between the levels of responsibility in which engineers operate at in the workplace and if they had achieved professional registration status. The research also identified possible methods to assist candidate engineers in obtaining professional registration. These findings are discussed in the following sections.

5.2. **Problem Statement and Research Questions**

The research was conducted around the following problem statement:

**Graduate engineers are expected to operate as professional engineers within a time-frame of approximately 3 years after graduation; however the opportunity to develop themselves into professional engineers within this time-frame is not currently achieved in the working environment.**

The research problem above stated that graduate engineers who entered the labour market were not being provided with the necessary development from their organisations to assist them in obtaining professional registration at the end of a 3 year period. The research set out to determine if this problem statement was true regarding engineers in South Africa. It provided the idea around which literature was collected and questions which were asked to engineers in South Africa through the use of a survey. This helped determine the validity of the problem statement and possible solutions to it.

Further to the problem statement above and in an effort to determine solutions to the development of graduate engineers in the workplace, the following research questions were investigated:
1. **Research Question 1** – What levels of responsibility are engineers expected to operate at in the workplace from the time of graduating to the time of registering as a professional engineer?

2. **Research Question 2** - What levels of responsibility do engineers actually operate at in the workplace from the time of graduating to the time of registering as a professional engineer?

3. **Research Question 3** – How can the development of engineering skills be facilitated in the working environment, to ensure that engineers operate at the appropriate levels of responsibility in order to achieve professional engineering status?

Research question 1 was aimed at finding out what skills graduate engineers should be in possession of following graduation from university. It also aimed at finding out what levels of responsibility graduate engineers should be capable of operating at in the workplace, while trying to obtain professional registration with ECSA.

Research question 2 was aimed at finding out what levels of responsibility engineers actually operate at in the workplace. Comparisons could then be done to determine if there is a difference between the actual and the expected operating levels of responsibility in the workplace.

Research question 3 was aimed at finding the best possible methods which can be used by graduate engineers to ensure that they are working at the appropriate levels of responsibility in the workplace, so that they are able to obtain professional registration with ECSA within the required time frame.

Solutions to the research questions above addressed the problem statement by identifying the required skills that engineers should be capable of performing in the workplace. It identified the levels of responsibility which engineers are expected to operate at in order to obtain professional registration with ECSA. Research also identified the time period which engineers require to obtain professional registration, and determined the best possible methods to assist engineers with this process.

5.3. **Solutions to Research Questions**

The descriptions below state the solutions derived to the research questions.

This section highlights the trends discovered in South Africa regarding candidate engineers, professional engineers and engineers not registered with ECSA, in terms of their registration characteristics with the professional organization and their careers.

Table 47 below, presents the key trends identified for candidate engineers from the research conducted.
### Table 47 – Trends derived for candidate engineers

<table>
<thead>
<tr>
<th>TREND CATEGORY</th>
<th>CANDIDATE ENGINEERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering related working experience</td>
<td>Largely registered with ECSA but did not obtain professional registration in the suggested 3 year time period.</td>
</tr>
<tr>
<td>Estimated time to obtain professional registration</td>
<td>Majority estimated that they would take longer than 3 years to obtain professional registration.</td>
</tr>
<tr>
<td>Overall levels of responsibility in the workplace</td>
<td>Not always operating at the correct overall levels of responsibility in the workplace when compared to their expected levels of responsibility.</td>
</tr>
<tr>
<td>Opinions on levels of responsibility in the workplace</td>
<td>Did not have the confidence to operate at the correct overall levels of responsibility in the workplace when compared to their expected levels of responsibility.</td>
</tr>
<tr>
<td>Levels of responsibility for each ECSA outcome</td>
<td>The performing level of responsibility for each of the ECSA outcomes showed that they were not performing as expected.</td>
</tr>
<tr>
<td>Chosen support programs to obtain professional registration</td>
<td>Many were receiving active mentoring from senior professionals, to assist them in obtaining professional registration.</td>
</tr>
</tbody>
</table>

Table 48 below, expands on the specific ECSA outcomes in which candidate engineers were lacking knowledge, which was preventing them from obtaining professional registration with ECSA.

The outcomes highlighted in red, namely outcomes, 2, 6, 7, 10 & 11 showed the highest values of candidate engineers not operating at the performing level expected. These outcomes have been identified as the outcomes which candidate engineers in South Africa show the greatest lack of knowledge.
Table 48 – Problematic knowledge areas identified for candidate engineers

<table>
<thead>
<tr>
<th>ECSA OUTCOMES (Knowledge Areas) for PROFESSIONAL REGISTRATION</th>
<th>ENGINEERING RELATED WORKING EXPERIENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 – 12 months</td>
</tr>
<tr>
<td>1 To be able to define, investigate and analyse engineering problems.</td>
<td>Being Exposed &amp; Assisting</td>
</tr>
<tr>
<td>2 To be able to design and/or develop solutions to engineering problems.</td>
<td>Being Exposed &amp; Assisting</td>
</tr>
<tr>
<td>3 To be able to comprehend as well as apply knowledge; principles, specialist knowledge, jurisdictional and local knowledge.</td>
<td>Being Exposed &amp; Assisting</td>
</tr>
<tr>
<td>4 To be able to manage a part of or all of one or more engineering activities.</td>
<td>Being Exposed &amp; Assisting</td>
</tr>
<tr>
<td>5 To be able to communicate clearly with others in the course of relevant engineering activities.</td>
<td>Being Exposed &amp; Assisting</td>
</tr>
<tr>
<td>6 To be able to recognize and address the reasonably foreseeable cultural, social and the environmental effects of engineering activities.</td>
<td>Being Exposed &amp; Assisting</td>
</tr>
<tr>
<td>7 To be able to meet all of the legal and the regulatory requirements, as well as protect the health and safety of all persons in the course of relevant engineering activities.</td>
<td>Being Exposed &amp; Assisting</td>
</tr>
<tr>
<td>8 To be able to conduct engineering activities ethically.</td>
<td>Being Exposed &amp; Assisting</td>
</tr>
<tr>
<td>9 To be able to exercise sound judgement in the course of engineering activities.</td>
<td>Being Exposed &amp; Assisting</td>
</tr>
<tr>
<td>10 To be responsible for making decisions on part of or all of engineering activities.</td>
<td>Being Exposed &amp; Assisting</td>
</tr>
<tr>
<td>11 To be able to undertake the professional development activities which are sufficient to maintain and extend his or her engineering competence.</td>
<td>Being Exposed &amp; Assisting</td>
</tr>
</tbody>
</table>

The trends from Table 47 & 48 above are discussed in Sections 5.3.1 – 5.3.3 below.

5.3.1. Research Question 1

- Chapter 2, Tables 1, 5 & 6, display the outcomes which engineers should be capable of executing upon the completion of an accredited four year B.Sc. or B.Eng. Engineering program. It also shows the outcomes which engineers are expected to be capable of operating at in the workplace, in order to obtain professional registration with ECSA.

- From Chapter 2, Table 5 & Figure 3, ECSA suggests a 36 – 42 month time frame (3 – 3 ½ years) in which it expects graduate engineers in the workplace to develop themselves with the necessary engineering skills.
The research also reveals the levels of responsibility which candidate engineers are expected to operate at in the workplace.

- Research shows that engineers should operate at specific levels of responsibility in the workplace in the duration between graduation and professional registration.
  - These levels can be seen in Table 5 & Figure 3 of the literature review.
- Once engineers are able to operate at the highest levels of responsibility, i.e. the performing level for each of the ECSA outcomes, they should be able to obtain professional registration with ECSA.

5.3.2. Research Question 2

- Chapter 4, Tables 16 & 33, indicate that candidate and unregistered engineers were not always operating at the appropriate levels of responsibility in the workplace as suggested by literature.
- Candidate and unregistered engineers stated that they operate at a high overall level of responsibility in the workplace. From Tables 28 & 45, it was established that they actually do not operate at these levels of responsibility for each of the ECSA outcomes.
  - Tables 15, 16, 32 & 33 illustrate that they were not of the opinion they could operate at the expected levels suggested by literature.
- As per Chapter 4, Figure 24, professional engineers were largely found to be operating at the appropriate levels of responsibility in the workplace as suggested by literature.
  - Figure 24 shows that there were professional engineers who were not operating at the expected levels of responsibility in the workplace.
  - Figure 25 & Table 29, indicate that these professional engineers were not of the opinion they could operate at the levels suggested by literature.

5.3.3. Research Question 3

- As per Chapter 2, Section 2.6, various methods have been used in the past to assist graduate engineers develop their skills. This has been accomplished through the use of professional bodies, businesses and universities.
- Chapter 4, Figure 21, indicates that the majority of candidate engineers receive active mentoring from senior professionals to assist them in obtaining professional registration with ECSA.
- Chapter 4, Figure 27, shows that professional engineers were assisted in achieving professional registration by receiving active mentoring from senior professionals in their organisations.
  - As per Figure 28, they also recommended this type of support to candidate engineers who are aiming to obtain professional registration.
- Chapter 4, Figure 34, indicates that unregistered engineers would consider receiving active mentoring from senior professionals, to assist them in obtaining professional registration.
5.4. **Research Outcome**

Based on the results received from the research conducted, it can be concluded that the problem statement is true in stating that graduate engineers are not operating as professional engineers within a time-frame of approximately 3 years after graduation. The opportunity to develop themselves into professional engineers within this time-frame is not currently achieved in the working environment.

From the research conducted it is possible to provide recommendations to graduate engineers aiming to obtain professional registration with ECSA in the future by making them aware of the registration trends with ECSA. These are discussed in Section 5.4 below.

5.5. **Recommendations**

The trends in Section 5.3 above are the key points which were established to determine recommendations to the research problem and research questions. Making use of the results received, recommendations can be produced, to assist graduate engineers in obtaining professional registration with ECSA in the suggested time-frame.

Development of an engineer should be driven by the engineering individual themselves, i.e. it is a self-development process [64]. It is the responsibility of the individual to ensure that they receive the adequate development from their organisations.

The ECSA outcomes are balanced so that a graduate engineer should develop both technically and personally in order to interact within a team. Graduates can then take responsibility for both technical (engineering) skills and soft/generic skills.

The recommendations are based on the research conducted and is highlighted in Figure 36 below. It addresses the research problem by showing how the research conducted can assist graduate engineers obtain professional registration in the required time period.

It guides graduate engineers and mentors by making them aware of the knowledge areas (ECSA Outcomes) which graduate engineers should develop, by operating at the appropriate levels of responsibility.

Candidate engineers are expected to go through the different levels of responsibility for the correct periods of time. This should be done until they are capable of operating at the performing level in each of the 11 ECSA outcomes. The knowledge areas which they are to be competent in are the 11 ECSA Outcomes as per Table 5, Chapter 2.
RECOMMENDATIONS FOR GRADUATE ENGINEERS

From the research conducted it is recommended that graduate engineers take note of the trends in South Africa for engineers aiming to obtain professional registration with ECSA.

These trends are:

1. Young engineers tend to register with ECSA; however there are still a large number of engineers who do not register with ECSA.
2. Candidate engineers do not obtain professional registration with ECSA in the required time period.
3. Whilst working at a high overall level of responsibility in the workplace, candidate engineers show a lack of knowledge in specific areas (ECSA Outcomes for professional registration).
4. Candidate engineers are expected to operate at the performing level in each of the 11 ECSA outcomes, however specific attention should be paid to the following knowledge areas:
   - The development of solutions to engineering problems.
   - The ability to address the effects of engineering activities.
   - The ability to adhere to regulatory requirements.
   - Personal attributes such as taking responsibility and making decisions.
   - Undertaking professional development to maintain engineering competence.
5. Research shows that a large amount of candidate engineers were not operating at the expected levels in the workplace for the above knowledge areas. It is deduced that the lack of knowledge in these areas prevented candidate engineers from obtaining professional registration with ECSA.

Figure 36 - Development recommendations to assist graduate engineers obtain professional registration
5.6. **Contributions of Research**

It can be stated that the research conducted was successful as it proved the problem statement and solved the research question. The research also investigated and derived trends relating to engineers in South Africa through the use of an online survey.

In addition to the above, the trends discovered from the survey are able to provide recommendations to graduate engineers as well as engineers aiming to obtain professional registration with ECSA.

- Engineers from the younger age groups show the greatest number of non-registrations with ECSA.
- Engineers, who are not registered with ECSA, have specific reasons as to why they feel registration is not important.

The main contributions of the research are directed toward candidate engineers, professional engineers and engineers not registered with ECSA. These contributions are as per Section 4.9, in Chapter 4 above.

Candidate engineers and many professional engineers were not able to obtain professional registration with ECSA in the suggested time-frame. Candidate engineers were not always operating at the appropriate levels of responsibility in the workplace. As a result of this, they were not able to obtain professional registration with ECSA in the required time period.

A number of candidate engineers were not being provided with the necessary development from their organisations to progress to a level of responsibility they felt they could operate at in the workplace. As deduced in Section 4.9, Chapter 4 above, it was proven that the major knowledge areas in which candidate engineers were lacking the ability to operate at the performing level emanated from:

- The development of solutions to engineering problems.
- The ability to address the effects of engineering activities.
- The ability to adhere to regulatory requirements.
- Personal attributes such as taking responsibility and making decisions.
- Undertaking professional development to maintain engineering competence.

It was concluded that the most used and recommended method of assisting engineers obtain professional registration with ECSA was through active mentoring from senior professionals.

5.7. **Possible Future Research**

Obtaining professional registration with ECSA provides an engineer the opportunity to be able to work responsibly without supervision and take responsibility for engineering decisions. This can be a stepping stone to engineering leaders and to developing leaders in an engineering environment.
Engineering management teaches us that engineers are not good managers [65]. Engineers who prove that they are professionally competent in engineering could have a solid foundation to build their leadership and management skills. This can assist them in operating successful organisations in the South African engineering industry.

Possible future research can be carried out on understanding the reasons why candidate engineers show a lack of knowledge in ECSA outcomes 2, 6, 7, 10 & 11. Once this is understood, it may be possible to provide graduate engineers in South Africa with a development framework to assist them in obtaining professional registration with ECSA in the required time-frame.

A secondary research direction could be undertaken, whereby graduate/candidate engineers in the industry make use of the recommendations provided from this research. They would need to ensure that they develop themselves in the workplace with the aim of achieving professional registration within the 3 year period. This could be carried out to identify any additional actions which can be taken to further accelerate the development of graduate engineers into professional engineers.
6. References


October 2015).


7. Appendixes

7.1. Appendix A – Engineers Questionnaire
QUESTIONNAIRE ON THE DEVELOPMENT OF ENGINEERS

* Required

DEVELOPING GRADUATE ENGINEERS INTO PROFESSIONAL ENGINEERS

The purpose of this survey is to determine trends in South Africa with regards to the professional registration with ECSA of B.Sc. and B.Eng. Engineering professionals.

My name is Nishaal Rooplall and I am currently busy doing research under the supervision of Dr. A. Mamewick in an effort to complete my dissertation for a Master’s Degree in Engineering Management at the University of Johannesburg.
I would like to sincerely thank you for taking the time to participate in this survey.

Participants:
- B.Sc. and B.Eng. Graduate Engineers in the South African working industry.
- B.Sc. and B.Eng. Professional Engineers in the South African working industry.

Principles:
- All of the data collected will be kept confidential.
- The collective analysed findings of the data collected could be made available in a public report.

Contact Person:
Mr. Nishaal Rooplall
SECTION 1:

DEMOGRAPHIC INFORMATION

1. Please select your age group *
   Mark only one oval.
   - Younger than 20 years old
   - 21 - 29 years old
   - 30 - 39 years old
   - 40 - 49 years old
   - 50 - 59 years old
   - 60 years old and older

2. Please select your gender. *
   Mark only one oval.
   - Male
   - Female

SECTION 2

ACADEMIC INFORMATION

3. What is your highest qualification obtained? *
   Please select an option below.
   Mark only one oval.
   - B.Sc./B.Eng. Engineering Degree
   - A BTech Engineering Degree
   - A Honours Engineering Degree
   - A Masters Engineering Degree
   - A Doctoral Engineering Degree
   - Other: ........................................................................................................

4. When did you obtain this qualification *
   You may select any date and month, as only the year will be noted

   Example: December 15, 2012
5. **Which industry are you currently employed in?** *
   Please select an option below.
   *Mark only one oval.*
   - Information and Communications Technology (ICT)
   - Finance and Banking
   - Energy and Utilities
   - Government, Public Sector & Defence
   - Mining & Commodities
   - Transport
   - Retail and Wholesale
   - Construction and Civil Engineering
   - Consulting or professional services
   - Fast Moving Consumer Goods (FMCG)
   - TMT (Technology, Media and Entertainment)
   - Other: ........................................................................................................

6. **Are you registered with ECSA?** *
   Please select an option below.
   *Mark only one oval.*
   - Yes  
     [Link: Skip to question 7.]
   - No  
     [Link: Skip to question 9.]

---

**Section 2.1**

**Registered with ECSA**

7. **Which year did you register in?** *
   You may select any date and month, as only the year will be noted
   
   *Example: December 15, 2012*

8. **Are you currently registered as?** *
   Please select an option below.
   *Mark only one oval.*
   - Candidate engineer  
     [Link: Skip to question 11.]
   - Professional engineer  
     [Link: Skip to question 19.]
   - Other: ........................................................................................................  
     [Link: Skip to "THE END."]

---

**Section 2.2**

**Not registered with ECSA**

9. **Are you considering registering with ECSA?** *
   Please select an option below.
   *Mark only one oval.*
   - Yes
   - No
10. Please select the most fitting reason as to why you haven’t registered with ECSA. *
   Please select an option below.
   Mark only one oval.
   - [ ] Don’t understand the registration process  
     Skip to question 26.
   - [ ] Not interested in registering  
     Skip to question 26.
   - [ ] Not a requirement/necessity  
     Skip to question 26.
   - [ ] I am considering registering with ECSA soon  
     Skip to question 26.
   - [ ] Other:  
     Skip to question 26.

SECTION 3
CANDIDATE ENGINEER CAREER INFORMATION

11. What is your engineering related work experience since graduation? *
   Please select an option below.
   Mark only one oval.
   - [ ] 0-6 months
   - [ ] 6-12 months
   - [ ] 12-18 months
   - [ ] 18-30 months
   - [ ] 30-36 months
   - [ ] 36+ months

12. In your own estimate, by when do you hope to achieve professional engineering status with ECSA? *
   You may select any date and month, as only the year will be noted.
   Example: December 15, 2012

13. Select the description that best describes your level of responsibility at work. *
   Mark only one oval.
   - [ ] Induction/ Observation (Being exposed)
   - [ ] Performing under close supervision (Assisting)
   - [ ] Performing under limited supervision (Participating)
   - [ ] Performing with approval of work output (Contributing)
   - [ ] Working without supervision (Performing)

14. In your opinion, given your work experience and academic history, what level of responsibility do you feel you should be at? *
   Please select an option below.
   Mark only one oval.
   - [ ] Induction/ Observation (Being exposed)
   - [ ] Performing under close supervision (Assisting)
   - [ ] Performing under limited supervision (Participating)
   - [ ] Performing with approval of work output (Contributing)
   - [ ] Working without supervision (Performing)
15. If applicable, what is preventing you from operating at the level you feel you should be at? Please give a few reasons.
If there isn't anything preventing you from operating at your desired level, please type the word 'Nothing' below.

............................................................................................................................
............................................................................................................................
............................................................................................................................
............................................................................................................................
............................................................................................................................
16. **Please rate your level of responsibility, in your work environment, as per the 11 outcomes as set out by ECSA.**

*Mark only one oval per row.*

<table>
<thead>
<tr>
<th>Induction/Observation (Being exposed)</th>
<th>Performing under close supervision (Assisting)</th>
<th>Performing under limited supervision (Participating)</th>
<th>Performing with approval of work output (Contributing)</th>
<th>Working without supervision (Performing)</th>
</tr>
</thead>
<tbody>
<tr>
<td>To be able to define, investigate as well as analyse engineering problems.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>To be able to design and/or develop solutions to engineering problems.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>To be able to comprehend as well as apply knowledge; principles, specialist knowledge, jurisdictional and local knowledge.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>To be able to manage a part of or all of one or more engineering activities.</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>To be able to communicate clearly with others in the course of relevant engineering activities.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>To be able to recognize as well as address the reasonably foreseeable cultural, social and the environmental effects of engineering activities.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>To be able to meet all of the legal and the regulatory requirements, as well as protect the health and safety of all persons in the course of engineering activities.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
relevant engineering activities.
To be able to conduct engineering activities ethically.
To be able to exercise sound judgement in the course of engineering activities.
To be responsible for making decisions on part of or all of engineering activities.
To be able to undertake the professional development activities which are sufficient to maintain as well as extend his or her engineering competence.

17. In order to prepare yourself for professional registration, are you formally part of any development programs from the list below? *
Please select from the options below. Check all that apply.

- Private mentorship for graduates through the professional body such as the ECSA candidacy program
- Professional body candidacy programs which are specific to the relative field of engineering.
- Active mentoring from senior professionals within the organization
- Watch/shadow senior engineering professionals in the organization
- In-house Graduate development programs
- In-house mentorship for graduates starting their careers through the use of previous graduate engineers
- Industry training and development as per professional body requirements as part of the engineering qualification.
- Not supported by any of the above

18. Are you directly responsible for the development of any graduate engineers in your organization? *
Please select an option below. Mark only one oval.

- Yes  Skip to "THE END."
- No   Skip to "THE END."
SECTION 4
PROFESSIONAL ENGINEER CAREER INFORMATION

19. What is your engineering related work experience since graduation? *
   Please select an option below.
   Mark only one oval.
   ○ 3-5 years
   ○ 5-7 years
   ○ 7-10 years
   ○ 10+ years

20. Select the description that best describes your level of responsibility at work. *
   Mark only one oval.
   ○ Performing under limited supervision (Participating)
   ○ Performing with approval of work output (Contributing)
   ○ Working without supervision (Performing)

21. In your opinion, given your work experience and academic history, what level of responsibility do you feel you should be at? *
   Please select an option below.
   Mark only one oval.
   ○ Performing under limited supervision (Participating)
   ○ Performing with approval of work output (Contributing)
   ○ Working without supervision (Performing)

22. How long after initially registering with ECSA as a candidate engineer, did you obtain Professional Registration? *
   Please select an option below.
   Mark only one oval.
   ○ 3-5 years
   ○ 5-7 years
   ○ 7-10 years
   ○ 10+ years
23. **During the time in which you prepared yourself towards professional engineering status, were you supported by any of the following development programs?** *
   Please select from the options below. 
   *Check all that apply.*
   - Private mentorship for graduates through the professional body such as the ECSA candidacy program
   - Active mentoring from senior professionals within the organization
   - Watch/shadow senior engineering professionals in the organization
   - In-house Graduate development programs
   - In-house mentorship for graduates starting their careers through the use of previous graduate engineers
   - Industry training and development as per professional body requirements as part of the engineering qualification.
   - Not supported by any of the above

24. **From your experience of registering as a Professional Engineer, do you have any suggestions for graduates, as to the best methods for obtaining Professional Registration?** *
   Please select from the options below. 
   *Check all that apply.*
   - Private mentorship for graduates through the professional body such as the ECSA candidacy program
   - Active mentoring from senior professionals within the organization
   - Watch/shadow senior engineering professionals in the organization
   - In-house Graduate development programs
   - In-house mentorship for graduates starting their careers through the use of previous graduate engineers
   - Industry training and development as per professional body requirements as part of the engineering qualification.
   - No suggestion
   - Other: .................................................................

25. **Are you directly responsible for the development of any graduate engineers in your organization?** *
   Please select an option below. 
   *Mark only one oval.*
   - Yes Skip to “THE END.”
   - No Skip to “THE END.”

**SECTION 5**
Unregistered Engineers
26. **What is your engineering related work experience since graduation?**
   Please select an option below.
   *Mark only one oval.*
   - [ ] 0 - 3 years
   - [ ] 3-5 years
   - [ ] 5-7 years
   - [ ] 7-10 years
   - [ ] 10+ years

27. **Select the description that best describes your level of responsibility at work.**
   Please select an option below.
   *Mark only one oval.*
   - [ ] Induction/ Observation (Being exposed)
   - [ ] Performing under close supervision (Assisting)
   - [ ] Performing under limited supervision (Participating)
   - [ ] Performing with approval of work output (Contributing)
   - [ ] Working without supervision (Performing)

28. **In your opinion, given your work experience and academic history, what level of responsibility do you feel you should be at?**
   Please select an option below.
   *Mark only one oval.*
   - [ ] Induction/ Observation (Being exposed)
   - [ ] Performing under close supervision (Assisting)
   - [ ] Performing under limited supervision (Participating)
   - [ ] Performing with approval of work output (Contributing)
   - [ ] Working without supervision (Performing)

29. **If applicable, what is preventing you from operating at the level you feel you should be at?**
   Please give a few reasons.
   If there isn't anything preventing you from operating at your desired level, please type the word 'Nothing' below
   
   -------------------------------------------------------------------------------------------------------------------------------------
   
   -------------------------------------------------------------------------------------------------------------------------------------
   
   -------------------------------------------------------------------------------------------------------------------------------------
   
   -------------------------------------------------------------------------------------------------------------------------------------
   
   -------------------------------------------------------------------------------------------------------------------------------------
30. **Please rate your level of responsibility, in your work environment, as per the 11 outcomes as set out by ECSA.**

*Mark only one oval per row.*

<table>
<thead>
<tr>
<th>Induction/Observation (Being exposed)</th>
<th>Performing under close supervision (Assisting)</th>
<th>Performing under limited supervision (Participating)</th>
<th>Performing with approval of work output (Contributing)</th>
<th>Working without supervision (Performing)</th>
</tr>
</thead>
<tbody>
<tr>
<td>To be able to define, investigate as well as analyse engineering problems.</td>
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<tr>
<td>To be able to design and/or develop solutions to engineering problems.</td>
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<td>To be able to comprehend as well as apply knowledge; principles, specialist knowledge, jurisdictional and local knowledge.</td>
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<td>To be able to manage a part of or all of one or more engineering activities.</td>
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<tr>
<td>To be able to communicate clearly with others in the course of relevant engineering activities.</td>
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<tr>
<td>To be able to recognize as well as address the reasonably foreseeable cultural, social and the environmental effects of engineering activities.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>To be able to meet all of the legal and the regulatory requirements, as well as protect the health and safety of all persons in the course of</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
31. **If you were to register as a Professional Engineer, which of these options would you consider to be the best support to accelerate your professional registration?** *

Please select from the options below. 
*Check all that apply.*

- [ ] Private mentorship for graduates through the professional body such as the ECSA candidacy program
- [ ] Active mentoring from senior professionals within the organization
- [ ] Watch/shadow senior engineering professionals in the organization
- [ ] In-house Graduate development programs
- [ ] In-house mentorship for graduates starting their careers through the use of previous graduate engineers
- [ ] Industry training and development as per professional body requirements as part of the engineering qualification.
- [ ] No suggestion

32. **Are you directly responsible for the development of any graduate engineers in your organization?** *

Please select an option below.
*Mark only one oval.*

- [ ] Yes  
  *Skip to “THE END.”*
- [ ] No  
  *Skip to “THE END.”*

**THE END**

Thank you for taking the time to complete this questionnaire. Your time and effort is
Please remember to forward this questionnaire to your own colleagues and friends.

Responses from as many engineers as possible will greatly enhance the results of this survey and contribute to my dissertation.

Powered by

Google Forms
7.2. **APPENDIX B – ALPHA-CRONBACH RELIABILITY RESULTS FOR CANDIDATE ENGINEERS**
RELIABILITY
/VARIABLES=Outcome1 Outcome2 Outcome3 Outcome4 Outcome5 Outcome6 Outcome7
Outcome8 Outcome9
Outcome10 Outcome11
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/MODEL=ALPHA
/STATISTICS=DESCRIPTIVE SCALE CORR
/SUMMARY=TOTAL.

Reliability

Notes

Output Created 20-APR-2016 18:03:48

Comments

Input
Active Dataset
Filter
Weight
Split File
N of Rows in Working Data File
Matrix Input

Missing Value Handling
Definition of Missing
Cases Used

User-defined missing values are treated as missing.
Statistics are based on all cases with valid data for all variables in the procedure.
RELIABILITY
/VARIABLES=Outcome1 Outcome2 Outcome3 Outcome4 Outcome5 Outcome6 Outcome7
Outcome8 Outcome9
Outcome10 Outcome11
/SCALE('ALL VARIABLES') ALL
/MODEL=ALPHA
/STATISTICS=DESCRIPTIVE SCALE CORR
/SUMMARY=TOTAL.

Scale: ALL VARIABLES
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<sup>a</sup> Listwise deletion based on all variables in the procedure.

## Reliability Statistics

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## Item Statistics

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## Inter-Item Correlation Matrix

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Page 2
### Item-Total Statistics

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'Academic Documents\Nishaal Rooplall - MPhil Documents\Dissertation\Candidate Engineers - 173.sav'
/COMPRESSED.
7.3. **APPENDIX C – ALPHA-CRONBACH RELIABILITY RESULTS FOR UNREGISTERED ENGINEERS**
GET
FILE='C:\Users\Nishaal.Rooplall\Dropbox\Nishaal Rooplall - Academic Documents\Nishaal Rooplall - MPhil Documents\Dissertation\Candidate Engineers - 173.sav'.
DATASET NAME DataSet1 WINDOW=FRONT.
RELIABILITY
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/SCALE('ALL VARIABLES') ALL
/MODEL=ALPHA
/STATISTICS=DESCRIPTIVE SCALE CORR
/SUMMARY=TOTAL.

### Reliability

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Scale: ALL VARIABLES

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a. Listwise deletion based on all variables in the procedure.

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