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Industry preferences of future Engineering Leadership Education in South African tertiary institutions

By

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Abstract

The engineering profession is vital to the health, safety and development of a country. It creates vision and shapes public policy. The Engineering Council of South Africa (ECSA) requires candidate engineers to display ‘leadership’ as a professional competency, in terms of the ‘New Registration System’. South African engineering schools presently do not offer any formal Engineering Leadership Education (ELE) to undergraduates, in contrast with current international best practice and global trends. The aim of this study was to investigate a preferred framework for future ELE locally, based on international best practices and the views of the ECSA membership. A literature review of international professional registration guidelines and ELE programmes with regards to best practice was undertaken. More specifically, a focus was placed on the various programmes’ approaches, goals, themes and the specific competencies developed. Theory around leadership competency development was also explored, including the Skills Approach and associated capability models. The study was underpinned by a functionalist paradigm with a pragmatic, quantitative approach to answering the research questions. An online survey instrument was created and then distributed via various local engineering associations to their membership databases for participation. The target population for the study was the South African engineering industry represented by the ECSA membership across all disciplines. The sampling method employed was the simple random method where 339 valid responses were received and processed, translating to a 90.16% response rate. The collected data was analysed using a statistical software package, SPSS version 26.0. The study found that there is an overwhelming desire for ELE to be implemented locally, with the majority of the industry perceiving current graduates to possess little leadership knowledge and competence. The industry also showed preference to themes including ethical leadership, professional accountability and project management skills that they believe should be included within any future ELE programmes. In addition, conventional methods of implementation were also preferred, including mentoring programmes, work experience and development plans. However, it is recommended that this must be accompanied with well-structured theoretical knowledge delivered through specific Engineering Leadership coursework to provide a foundational standardisation and an opportunity to monitor improvement.

Keywords: *ECSA, ELE, Leadership competency, Leadership development, Leadership education*

Table of Contents

Table of Contents

Description	**Page**

Table of Contents

Table of Contents

List of Figures

List of Figures

List of Tables

List of Tables

List of Tables

List of Abbreviations

Abbreviation	Meaning
AeSSA	Aeronautical Society of South Africa
ASCE	American Society of Civil Engineers
CA	Candidate Academy
CHE	Council on Higher Education
ECSA	Engineering Council of South Africa
ELC	Engineering Life Cycle
ELDM	Engineering Leadership Development Minor
ELE	Engineering Leadership Education
ELP	Engineering Leadership Programme
EPA	Engineering Profession Act, 2000 (No. 46 of 2000)
GELs	Gordon Engineering Leaders
Gordon-MIT EPL	Gordon – MIT Engineering Leadership Program
IEA	International Engineering Alliance
ISU	Iowa State University
MIT	Massachusetts Institute of Technology
NASA	National Aeronautics and Space Administration
NRS	New Registration System
NSPE	National Society of Professional Engineers
SA	South Africa
SAICE	South African Institute of Civil Engineers
SAIEE	South African Institute of Electrical Engineers
SAIIE	South African Institute of Industrial Engineers
SAIMechE	South African Institute of Mechanical Engineers

CHAPTER ONE
Introduction

1.1 Introduction

South African tertiary education institutions do not offer any explicit or non-explicit forms of Engineering Leadership Education (ELE) to undergraduate engineers, as recognised by Graham, Crawley and Mandelsohn (2009: p.12) at the time of their significant global study into the topic. Upon a review of current local engineering programmes and from the apparent absence of local literature regarding the topic of ELE, it is evident that the situation has, to date, remained largely unchanged in this regard. This is in contrast to international trends to recognise and implement ELE in an effort to produce high performance engineers who are globally competitive and possess the ability and "confidence to create, innovate and collaborate to deliver world changing solutions" (Kotnour, Hoekstra, Reilly, Knight & Selter, 2014: 56). The local statutory engineering body, the Engineering Council of South Africa (ECSA), recognises leadership competency as a requirement for professional registration (ECSA, 2018a: 15). However, the body does not detail or significantly emphasise the topic when compared to other international engineering associations, thereby ELE eludes the attention of local engineering schools. In this respect there is presently an Engineering Leadership knowledge gap experienced by graduate engineers of South African engineering schools and, by implication, the local engineering profession in general. Awareness therefore needs to be raised locally regarding prevalent world trends related to ELE and the vital need for local engineering tertiary education institutions to meet the new international leadership development standards. This chapter outlines the motivation, scope, purpose and objectives of the study. In addition, the limitations experienced while exploring the topic of ELE, and proposing a coherent focus and framework to ELE for South African tertiary education institutions will be discussed.

1.2 Motivation for the Study

The motivation underpinning this study was founded on the researcher's career experience and the shared views discovered in available literature on the topic. Engineers are predominantly rigorously trained in technical skills yet receive little to no explicit leadership development (Graham, et al., 2009: 12). This is more so the case at an undergraduate level within the South African context. However, leadership development through ELE has been identified by international engineering authorities, such as the National Society of Professional Engineers (NSPE) in the United States of America, as being important to develop engineering leaders capable of rising to the challenges of the day and maintaining a competitive edge (NSPE, 2010: 2). ECSA recognises leadership competency as imperative therefore this competency forms part of the requirements for professional registration with the statutory body. However the guidelines lack rigorous detail of what leadership competency entails (Candidate Academy, 2013: 27; ECSA, 2018a: 15). The means of leadership development, and its assessment for professional registration, are vague and non-existent, respectively. This could be a significant contributing factor as to why the important topic falls outside the engineering curriculum of tertiary institutions locally. In contrast, international statutory engineering bodies and educational institutions such as the American Society of Civil Engineers (ASCE) are increasing their explicit leadership development initiatives and accreditation criteria at a foundation level (ASCE, 2008: 145).

This study was undertaken with the intention of benefiting future South African graduate engineers, by suggesting initiatives that could be implemented to increase their ability to be internationally competitive leaders. More readily the study sought to benefit ECSA by proposing a framework and focus for ELE locally, which is currently absent in registration and other guidelines. Local tertiary education institutions offering engineering may benefit directly from this study in developing their own ELE programmes by considering the international best practices and industry preferences determined by surveying local engineering practitioners explored here. Local employers of future graduate engineers in both the public and private sector may benefit from the implementation of the recommendations made in this study in developing ELE programmes, which would hopefully result in engineers possessing greater leadership competency from the onset. Due to the recognised lack of familiarity of South African engineers with the topic of ELE it is also intended that respondents in the survey employed in the study would benefit by being introduced to the topic. The unique contribution of this study would see it inform future ELE programmes locally, from the preferred goals and themes of any new ELE programmes, to informing the selection of effective approaches available based on international best practices.

1.3 Scope of the Study

The scope of the study was geared toward investigating a preferred framework to mainstream leadership development for South African engineers through ELE at the undergraduate phase. The study investigates existing international best practice of ELE which could be adapted and implemented locally to improve leadership competency in the build-up to the candidacy phase and subsequent professional registration with ECSA. A focus on the framework of these ELE programmes broadly included investigating their goals and approaches, and the resultant leadership competencies intended to be developed by engineers. The study excluded investigating any external and/or non-specific leadership development or education which may be voluntarily sought by individual engineers for personal and professional development. A focus was placed on theory associated with leadership competency development, namely the skills based model, while an inborn traits approach to leadership was rejected in the study.

This study focused on South African engineering practitioners comprising a volunteering sample from the membership of ECSA, who were surveyed to determine their preferences with regard to ELE. Local engineers across all disciplines participated thus the study placed emphasis on industry-wide needs and preferences of ELE. Tertiary education institutions were not approached to assess the views of local engineering schools specifically with regard to ELE in this study.

1.4 Problem Statement of the Study

Engineering Leadership is increasingly required of South African engineers in order for them to remain globally competitive and to continue to contribute to the positive development of the country (Planting, 2018: 1). Unfortunately, at present there is no explicit ELE offered within South African engineering schools to improve leadership development and competency (Graham, et al., 2009: 12). International universities, on the other hand, are enhancing their ELE programmes and minimising the gap between soft and technical competencies of their graduates (Paul & Falls, 2015a: 1). Further, the statutory body for engineering in SA, ECSA, identifies leadership competency as a requirement for professional registration of engineers, according to the New Registration System (NRS) of 2012, but does not provide sufficient detail about how this leadership competency should be developed and assessed (ECSA, 2018a: 15). The challenge in this study was therefore to investigate international best practice with regard to ELE and gain an understanding of South African Engineering Leadership needs and preferences to identify a possible framework which local educational institutions may use to formulate and implement their own ELE programmes.

This study therefore undertook to investigate ECSA members' preferred framework for ELE within South African tertiary education institutions, based on international best practice.

1.5 Purpose Statement of Study

The overall intention of this study was to understand international best practices with regards to ELE and to derive a preferred framework based on these, which in future could be implemented by the local engineering industry. Particular consideration was given to the goals, themes, approaches and leadership competencies associated with these existing ELE programmes. Any proposed focus and approach to ELE was centred on the preferences and needs indicated by members of ECSA who comprised the target population for the survey research that was conducted.

1.6 Research Objectives

The research objectives of this study are as follows:

- To identify what is meant by 'leadership' competency as a requirement for professional registration of engineers, by ECSA;
- To identify what dimensions of leadership competency are delivered through international best practices of ELE;
- To determine what the perceived current level of leadership capabilities (or gaps) is in present graduate engineers from South African tertiary institutions, by members of ECSA;
- To determine what the consensus is among the ECSA membership about any possible implementation of ELE within South African tertiary institutions; and
- To formulate and recommend ECSA members' preferred framework of ELE based on international best practices, which could be implemented in South African tertiary institutions.

1.7 Research Questions

The specific research questions of the study are as follows:

1.7.1 What is meant by 'leadership' competency as a requirement for professional registration of engineers, by ECSA?

1.7.2 What dimensions of leadership competency are delivered through international best practices of ELE?

1.7.3 What is the perceived current level of leadership capabilities (or gaps) in present graduate engineers from South African tertiary institutions, by members of ECSA?

1.7.4 What is the consensus among the ECSA membership about any possible implementation of ELE, within South African tertiary institutions?

1.7.5 What is ECSA members' preferred framework of ELE based on international best practices, which could be implemented in South African tertiary institutions?

1.8 Limitations of Study

In proceeding with the study there were limitations encountered in the research which had to be taken into account. Firstly, due to the relative lack of awareness locally of the topic, ELE, there is very little local research and literature available. The study thus predominantly relied on appropriate international literature. A further limitation was that due to the nature of research and the use of a survey, only an understanding of current opinions regarding the areas tested is gained, and these opinions may change in time based on circumstances facing the engineering industry. While efforts to maintain the quality of the research was of primary importance the possibility of researcher bias was still a risk. The difficulty associated with having full correspondence and adequate participation from the target population to gain the required minimum sample size over the research time frame proved difficult, but was however not a significant limitation to the results of the study.

1.9 Structure of the Dissertation

This research study is articulated across six chapters including this Introduction chapter. The subsequent chapters relate the following information and aspects of the study:

Chapter 2 – Literature Review:
A critical review of the existing literature is presented relating to current understandings of leadership, in particular Engineering Leadership. The specific competencies and dimensions of leadership that are instilled through ELE programmes internationally is considered, and relevant theory, that is the Skills Model and other capability models, are drawn upon to create a foundation around which the research is conducted.

Chapter 3 – Research Methodology:
The functionalist research paradigm underpinning the research is explored before a consideration of the descriptive, survey strategy used in the study is undertaken. The specific methods and techniques involved in sampling, data collection using the

survey method, and the statistical analysis and reporting of the data are detailed. Further, the chapter considers all reliability, validity and ethical considerations encountered in the study and how these were mitigated.

Chapter 4 – Presentation of Results:
The survey data of the study is quantitatively analysed in Chapter 4 and presented from both a descriptive and inferential statistics point of view. The chapter is structured such that relevant components of the sought-out framework may be deduced.

Chapter 5 – Discussion of Results:
The results of the survey on ECSA members' perceptions on the need for ELE in tertiary institutions locally are explored critically in this chapter to deliver the most useful findings of the study. The individual components of each section of the survey tested to finally answer the research questions are described fully in terms of the descriptive and inferential results, such that conclusions may be drawn in the subsequent chapter.

Chapter 6 – Conclusions and Recommendations:
A summary of the findings, discussion and recommendations regarding ELE, in line with the study objectives, is outlined in this chapter. The research questions are answered in light of the data collected in the study, existing literature and the researcher's viewpoints, and a preferred framework based on the survey results is suggested. Detailed recommendations for the relevant stakeholders of the study are provided based on the findings. Additional future work required regarding the research topic are also outlined.

1.10 Conclusion

The study undertook to explore international ELE best practice and preferences thereof by the South African engineering industry, for possible future implementation locally. Engineering Leadership needs to be prioritised alongside technical competencies in engineering education to produce engineers who will not only contribute innovatively to the country's growth, but will also rise to the new international leadership development standards.. The outcome of this study will help to provide an outline of various goals, themes and approaches to ELE which could assist in the creation and implementation of future ELE programmes locally. Based on the prospect of endeavouring into an uncharted space of ELE implementation in SA it was crucial to review the existing literature available on the topic, which is further discussed in the following chapter.

CHAPTER TWO

Literature Review

2.1 Introduction

Leadership competency is a registration requirement for South African engineers, among other professional competencies outlined by ECSA. This requirement is briefly mentioned in ECSA's 'Guide to the Competency Standards for Registration as a Professional Engineer' (ECSA, 2018a: 15) as well as the Candidate Academy's training guideline (Candidate Academy, 2013: 27). More so, international regulators such as the American Society of Civil Engineers' (ASCE) Body of Knowledge Committee, which sets out the prerequisites for professional registration of engineers in the United States, explicitly outline Engineering Leadership competency and prioritise it as a necessary outcome. The guidelines state that "the best place to start the formal leadership development process is at the undergraduate level" and that "leadership can be taught and learned" (ASCE, 2008:145). It is therefore acknowledged that the formal education process has the ability to significantly impart leadership principles and develop leadership attributes in engineers at a foundation level.

This chapter presents a review of literature pertinent to the topic of ELE. The chapter begins with an overview of general leadership and proceeds to a particular focus on Engineering Leadership. Thereafter leadership competencies and leadership dimensions will be discussed. Specific attention will be given to current circumstances locally with regards to ECSA's role in leadership development and considerations for any future implementation of ELE. Lastly, a review of the particular theory associated with leadership competency development, the Skills Model and associated capability models, is reviewed and incorporated throughout this chapter.

2.2 An Overview of Leadership

Theories regarding the topic of leadership and their evolution over time are of great interest and importance, especially currently in the contemporary modern era. Northouse (2016: 1) explains how the view of leadership has changed through the decades and how leadership is still a “highly sought-after commodity”. Northouse (2016: 2-5) describes the general components and process of leadership based on scholarly deductions over the recorded past. Earlier viewpoints of leadership related primarily to the centralisation of power and/or an individual’s specific personality traits (Northouse, 2016: 2-3). Subsequently the focus changed to the behaviour of a leader while directing a group to develop and execute their shared goals. Northouse (2016) suggests that there are various ways of conceptualising leadership, which are briefly outlined and critiqued below:

- Leadership as the ‘focus of group processes’. Here the leader is at the centre of the activity of the group and represents the will of the group (Northouse, 2016: 5). In contrast to such a viewpoint Platow, Haslam, Reicher and Steffens (2015: 20) explain that leadership is part of a group process, where followers are fundamental to the emergence and existence of a leader, through a shared group psychology.
- Leadership from a ‘personality perspective’. In this view the leader possesses special traits and characteristics which allow them to get others to accomplish tasks (Northouse, 2016: 5). Wajid (2019: 6) supports the notion that an effective professional leader possesses or develops qualities such as good “confidence, vision, communication, decision making ability, optimism, team work skills, understanding, proficiency, intellectual skills, cooperation, compassion, discipline, approachableness, emotional intelligence, empathy, honesty and ethicalness”.
- Leadership as an ‘act or behaviour’. This refers to the actions of a leader towards his or her followers in different contexts (Northouse, 2016: 5, 71). Ayman and Korabik (2010: 163) suggest that this approach manifests around the leader’s strive for effectiveness through aspects such as dedication and motivation, which positively influence and motivate followers.

- Leadership as a ‘power relationship’ between leader and followers. Leaders have power in the form of “referent, expert, legitimate, reward, coercive or information power” (Northouse, 2016: 5, 10) which is seen as a potential to influence followers. Orta (2015: 333) outlines additional external dynamics of power which affect leaders’ influence such as the existing organisational culture, information and communication technology available to followers, demographics of both leader and followers and lastly, economic factors which affect the organisation.
- Leadership as ‘a transformational process’ to move followers to achieve more than expected of them. This is often a ‘charismatic and visionary’ leadership approach which focuses on motivation and development of followers. This transformation is in regard to the human aspect of the followers including their “values, ethics, standards and long-term goals” (Northouse, 2016: 5,161). Zineldin (2017: 14) investigated the health psychology of transformational leadership within various organisations and found that inspirational and motivational leaders, through their behaviour and emotions, were able to positively increase job satisfaction, positive emotions and the extra effort of their followers.
- Leadership from a ‘skills perspective’. This dimension takes a leader-centred viewpoint where the skills, ability and knowledge of the leader result in effective leadership. This approach suggests that individuals can learn and develop the ability to become an effective leader (Northouse, 2016: 5, 43). Katz (1955: 33-42, cited in Northouse, 2016: 43-44) outlines the basic administrative skills as technical, human and conceptual skills required by leaders.

Northouse (2016: 6) ultimately defines leadership as “a process whereby an individual influences a group of individuals to achieve a common goal”. The ‘process’ of leadership refers to the “two-way interaction between leader and follower” (Northouse, 2016: 6). ‘Influence’ refers to the effect of leaders on their followers. ‘Group’, in Northouse’s (2016) understanding, refers to the context in which leadership takes place and it is affirmed that followers are necessary for leadership to exist. Lastly, ‘a common goal’ refers to the ethical component of leadership whereby leader and followers have a mutual purpose.

2.3 Engineering Leadership

Paul and Falls (2015a: 2) and Hartmann (2016: 10) are among many authors who view the position statement of the NSPE compiled in 2010 as a definition still relevant today and who believe that it asserts a call for 'Engineering Leadership'. Leadership in the context of engineering is defined by the NSPE (2010: 2) as the specific capabilities which are essential for professional engineers to "help create and communicate a vision for the future and the ability to help shape public policy". Further, good Engineering Leadership is seen as essential for the protection of the health, safety and welfare of the public during engineering professional practice. The published position statement outlines some of the necessary capabilities required of engineering leaders which include (NSPE, 2010: 2):

1) the ability to assess risk and take initiative;
2) the willingness to make decisions in the face of uncertainty;
3) a sense of urgency and will to deliver on time in the face of constraints or obstacles;
4) resourcefulness and flexibility;
5) trust and loyalty in a team setting and
6) the ability to relate to others.

According to Paul and Falls (2015a: 1), leadership capabilities, in addition to traditionally outlined engineering skills such as technical aspects, are important for innovation in engineering. These leadership skills are seen as valuable in a 21st century workplace regardless of whether engineers are pursuing management roles or technical team member positions. Emerging from their study was the postulation that effective engineering leaders are those who are able to enhance the engineering profession. This includes leaders' contributions to real world complex projects which pose challenges to humans. Engineering leaders were also highlighted as those individuals with a passion for technology and innovation who possess the ability to pioneer development and the implementation of new ideas. Paul and Falls (2015a: 5) further postulate that engineering leaders use 'system thinking' which refers to the integration of knowledge and skills across disciplines, from art to technology. This system thinking extends over and above the traditional understanding of engineers being groomed to think systematically and analytically.

Hartmann's (2016) study, which aimed to determine the viewpoints of engineering recruiters who specifically requested 'leadership' ability as a requirement of candidates in their advertised openings, gave insight into the industry needs of Engineering Leadership. The study found that collective themes of leadership requirements clearly emerged from these recruiters. Of particular priority was "initiative, confidence, good communication, interpersonal interaction, teamwork and engagement" (Hartmann, 2016: 24). Hartmann (2016: 9) also highlights that the ASCE has formalised these themes in the form of 'Outcome 20: Leadership', which is required for professional practice.

According to Hartmann (2016: 9), the ASCE's 'Civil Engineering Body of Knowledge', which represents the knowledge, skills and attitudes necessary for entry into professional practice, stipulates that 'leadership' is one of the twenty-four (24) outcomes required for professional registration. Leadership is described here as the ability of an engineer to "organise and direct the efforts of a group" (ASCE, 2008: 17). The ASCE (2008) explains that leadership is the ability to influence others towards accomplishing shared goals and does not necessarily originate from an appointed position. Engineers are expected to "lead when confronted with professional and/or ethical issues" (ASCE, 2008: 145). Here Engineering Leadership is also seen to be a particular set of responsibilities required of an engineering leader. Leadership is broadly described by the ASCE (2008: 145) to be:

1) developing and engaging others in a common vision;
2) clearly planning and organising resources;
3) developing and maintaining trust;
4) sharing perspectives;
5) inspiring creativity;
6) heightening motivation; and
7) being sensitive to competing needs.

The ASCE (2008: 145-146) highlights that engineers who, in addition to good design and analysis skills, possess high leadership skills, are increasingly sought after, because of their benefit in the early stages of new technologies, management models and organisational structures. Leadership is fortunately in itself also viewed by the ASCE as an outcome of engineering training where strong analytical skills and rational decision-making skills are seen to be the very nature of the profession. Here Engineering Leadership is viewed in terms of a particular set of central rules or principles that are required of an engineer. These leadership principles, which are seen as attainable through the engineering education process, include:

1) being technically competent;
2) knowing oneself and seeking self-improvement;
3) making sound and timely decisions;
4) setting the example;
5) seeking responsibility and taking responsibility for one’s actions;
6) communicating with and developing subordinates both as individuals and as a team; and
7) ensuring that the project is understood, supervised, and accomplished (ASCE, 2008: 145).

The ASCE (2008: 146) state that Engineering Leadership development is expected to be advanced from the tertiary education programmes during the ‘real-world’ work experience. Work experience is seen to enhance and reinforce the required qualities and attributes of engineering leaders which are also outlined by the ASCE and tabulated in Table 2.1 below.

Table 2.1: Important qualities and attributes of engineering leaders

Qualities and attributes of engineering leaders		
Vision	Enthusiasm	Industriousness
Initiative	Competence	Commitment
Selflessness	Integrity	High Ethical Standards
Adaptability	Communication Skills	Discipline
Agility	Confidence	Courage
Curiosity	Persistence	

Source: ASCE, 2008: 145-146.

Crumpton-Young, et al. (2010: 10) define Engineering Leadership as "the ability to lead a group of engineers and technical personnel who are responsible for creating, designing, developing, implementing and evaluating products, systems or services". The authors further explain that future success of business and industry will be influenced by engineers' knowledge of leadership and management principles. Effective leaders are seen to possess "written and oral communication skills, customer relations, personal initiative, teamwork abilities, organisational knowledge and decision-making skills" (Crumpton-Young, et al., 2010:10). According to Shaw (2003, cited in Hartmann, 2016: 26) an alternate definition of Engineering Leadership which is less people-centred is "a process of envisioning, designing, developing and supporting new products and services to a set of requirements and within budget and to a schedule with acceptable levels of risk to support the strategic objectives of an organisation". Here Engineering Leadership is shown to encompass the corporate strategy of the organisation.

Graham, et al. (2009: 6) highlighted another important dimension of Engineering Leadership as the increasing need for 'global awareness' and the ability to work on complex cross-national projects. Their study found that 'global engineering' was predicted as a future Engineering Leadership aspect of relevance (Graham, et al., 2009: 7). The authors found that engineers' ability to work in international, multidisciplinary teams with acknowledgement of different cultures is important for the way in which their respondents understood how engineering problems are to be approached in the future.

Sidhu (2015: 1) explains the shift in Engineering Leadership over recent history as changing according to the specific demands and opportunities available. Sidhu (2015) argues that there is therefore a need to rebalance Engineering Leadership with business leadership. The author suggests that a major driving point behind economic growth, national competitiveness and social benefit is that of technological innovation. Effective Engineering Leadership is seen as a means to achieve this innovation through product and service innovations and through production efficiency. Sidhu (2015: 1) explains that, historically, nations were built on engineering leaders who were inventors or orientated around production. Over time and with the development of professional business administration programmes a 'rebalancing of skill types' took place with industry leaders. The 1960's are described to have had market and sales-oriented engineering leaders who were focused on seeking out the greater market needs. The author adds that the 1980's saw engineering leaders evolve into leaders in finance who focused on corporate sector needs, such as company valuations and efficiency.

Sidhu (2015: 1) predicts that the next generation of innovators offering competitive advantage will come from engineering leaders with a combination of "technical horsepower, entrepreneurial ability and business judgement". Sidhu (2015: 3) adds that Engineering Leadership in the long term will also require communication and operational skills. Communication skills are seen as essential to engineering leaders in delivering both the technical and business sides of ideas to team members, clients, customers and other stakeholders. These communication skills also include "influence, negotiation and conflict resolution" (Sidhu, 2015: 4). Sidhu (2015) highlights that Engineering Leadership is carried out through communication however it is not limited to a person's appointed position within an organisation but rather the ability to demonstrate leadership proficiency. Here engineering leaders are seen to not just perform the 'worker bee' tasks of industry and society but also to add value to the industrial and social contributions which enhance a country. Sidhu (2015: 2) identifies the examples of successful organisations which have major economic and cultural influence in the world including global technology and industrial organisations that have maintained a balance of engineers in their leadership mix and have thus benefited greatly.

2.4 Leadership Competency and Dimensions

In describing the theory and practice of leadership and the various approaches to it, Northouse (2016: 43) outlines the Skills Approach which is seen as a focus on the leader's knowledge and abilities which translates into effective leadership. Northouse (2016) cites the work of Katz (1955) where this leader-centred approach of leadership is viewed as a set of 'developable' skills. Katz (1955: 34, cited in Northouse, 2016: 44) outlined the three-skill approach to describe leadership and administrative requirements of an organisation based on three groups of personal skills of a leader, namely technical, human and conceptual skills. Subsequent work carried out by Mumford, et al. (2000) gave rise to a more comprehensive Skills Model of leadership being outlined.

2.4.1 The Three-Skill Approach

Katz (1955: 34, cited in Northouse, 2016: 44) argues that the skills which form the makeup of the three-skill approach, rather than being in-born traits, can be achieved by individuals who aspire to leadership. This model emphasises the notion that leadership skills can be trained into individuals to create leaders (Northouse, 2016: 44). The three skills, namely technical, human and conceptual skills, are further explained in Figure 2.1 below. Additionally, Figure 2.1 illustrates the level of skills or competencies required by an effective leader at different levels of management within an organisation.

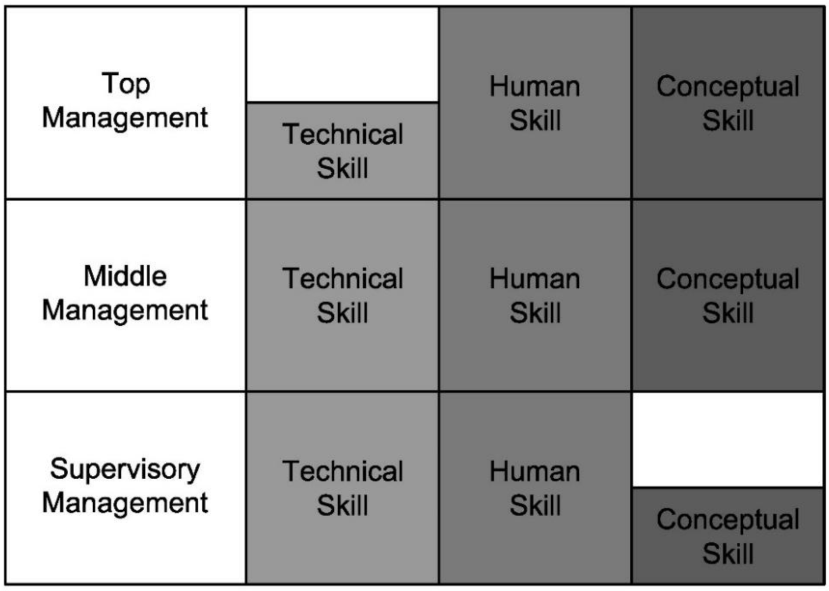


Figure 2.1: Balance of skills required at different levels of management
Source: Northouse, 2016: 46.

Technical skills are seen as important competencies in all levels of management, but less so in top management. The use of tools and techniques to perform specialised work with proficiency is viewed as critical for lower to middle management but are less utilised in upper management. These competencies include industry-specific knowledge and principles which are essential for the delivery of the desired products and services. In engineering these technical skills are traditionally incorporated into tertiary education programmes and/or developed during practice. Technical skills in the three-skill approach are viewed as discipline specific.

Human skills are referred to as the ability of a leader to work efficiently with people and are also known as ‘people skills’. Northouse (2016: 45) explains that the ability of leaders to work with followers, peers and superiors to achieve organisational goals is important. Katz (1955, cited in Northouse, 2016) states that leaders must be aware of their own perspective as well as that of others to be successful. Human skills involve a leader adapting their ideas to take into account the perspectives of others and being sensitive to their needs and motivation. Followers need to feel comfortable and secure in a leader’s approach. Human skills are thus seen as important at all levels of leadership from lower to upper management.

The conceptual skills component of the three-skill approach is explained by Northouse (2016: 45) as being the ability to work with ‘ideas and concepts’. Northouse (2016) argues that it is important for leaders to be able to discuss ideas which involve the organisation and the details of such ideas, that is, a leader should be able to engage in notions both abstract and hypothetical. An identified area in which effective leaders engage in conceptual skills is that of economic principles which affect their organisations. Conceptual skills are seen as vital for a leader to create a vision and strategic plan for an organisation, especially when functioning in a challenging environment (Northouse, 2016). Leaders are thus anticipated to display a high level of conceptual skills at upper management level with regard to organisational and policy issues. This is achieved by understanding what their specific organisations stand for and where its position is envisioned.

2.4.2 The Skills Model

Mumford, et al. (2000, cited by Northouse, 2016: 45) developed the Skills Model as a theory through which problem solving skills within an organisation could be addressed. The primary goal of their research was to explain the components of effective performance. Mumford, et al. (2000: 12) characterise the skills-based model of leadership as a ‘capability model’ as it examines the relationship of the leader’s knowledge and skills against his/her performance. This knowledge and related skills, according to the Skills Model, are thought of as ‘capabilities’. Leadership capabilities can be developed through education and experience and thus more people have the potential to become good leaders. The Skills Approach is based on the premise that knowledge and skills (capabilities) make individuals effective leaders, rather than other behavioural approaches which look at what individuals do to effect leadership.

The Skills Model comprises five components including “competencies (knowledge and skills), individual attributes, leadership outcomes, career experiences and environment influences” (Northouse, 2016: 47) which all form the bases of effective performance of leaders. Three components are specifically highlighted as essential to the skills-based leadership model, namely individual attributes, competencies and leadership outcomes, which are seen as the flow of attaining effective leadership.

Table 2.2 below provides a summary of the three important components of leadership according to the Skills Model. The three components are discussed in further detail in the subsections to follow.

Table 2.2: Components of skills based model

Individual Attributes	Competencies	Leadership Outcomes
General Cognitive Ability	Problem-Solving Skills	Effective Problem Solving
Crystallised Cognitive Ability	Social Judgement	Performance
Motivation	Knowledge	
Personality		

Source: Northouse, 2016: 48.

2.4.2.1 Individual Attributes

According to the Skills Model, individual attributes have an impact on a leader's skills and knowledge (Northouse, 2016: 52). These attributes include the leader's general cognitive ability, crystallised cognitive ability, motivation and personality. Complex problem solving is seen to become more necessary as one moves up the organisational hierarchy and a leader's individual attributes support his or her competencies.

Northouse (2016: 52) explains general cognitive ability as a leader's intelligence and it is believed to positively contribute towards complex problem-solving skills and knowledge. This general cognitive ability is further explained as being linked to an individual's perceptual processing, information processing, general reasoning skills, creative and divergent thinking capabilities and memory skills. An individual's general cognitive ability, in terms of the Skills Model, is thought to be linked to a leader's biology and not necessarily their experience. General cognitive ability expands through early adulthood and subsequently declines with age.

Crystallised cognitive ability in the Skills Model refers to a leader's intellectual ability which is learned over time and experience and includes leadership potential such as problem solving skills, conceptual ability and social judgement skills (Northouse, 2016). This ability grows with an individual into adulthood and, according to Northouse (2016: 52) includes the ability to “comprehend complex information and learn new skills and information”, in addition to being able to communicate with others in oral and written form. In contrast to general cognitive ability, crystallised cognitive ability is ‘acquired intelligence’ (ideas and mental abilities) gained through experience which remains with leaders as they get older.

Motivation is seen as a vital attribute of an individual to become a leader, as described by Mumford, et al. (2000: 12). Motivation, firstly, refers to the leader being ‘willing’ to face challenges experienced by the organisation and wanting to lead. Secondly motivation involves the leader’s willingness to show ‘dominance’ to influence followers to achieve goals. The influence gained is vital for leadership to exist. ‘Social good’ is also identified by Mumford, et al. (2000) as an important factor to which leaders must be committed for success It is viewed as the leader’s willingness to promote the all-round ‘human good and value’ within the organisation.

The last individual attribute described as being beneficial to leadership in the Skills Model is broadly referred to as ‘personality’ (Northouse, 2016: 53). Personality is placed early in the Skills Model and represents an individual’s development of leadership skills. Openness and curiosity are seen as examples of attributes which may increase a leader’s motivation to solve complex organisational problems. Additionally, confidence and adaptability are seen as personality characteristics which may assist leaders to resolve conflict situations. Mumford, et al. (2000) propose that any personality characteristic which assists a leader to address an organisational situation is probably linked to the leader’s performance.

2.4.2.2 Competencies

Individual attributes are believed to lead to ‘competencies’ in the Skills Model. Competencies are collectively seen to comprise problem-solving skills, social judgement skills and knowledge. These three competencies, in the Skills Model, are viewed as the central important factors which contribute positively to effective performance.

Problem-solving skills, according to Mumford, et al. (2000) and Northouse (2016: 48), refer to the leader's creative ability to solve new, unusual and ill-defined organisational problems. The skills of a leader to define, gather information, formulate a new understanding and develop prototype solutions to problems collectively contribute towards his or her problem-solving competency. The authors also suggest that leaders often execute problem-solving skills in the context of the organisation as a whole rather than within independent silos of the organisation. Leaders are expected to understand their own capabilities in order to successfully carry out problem-solving skills (Mumford, et al., 2000, cited by Northouse, 2016: 48). Problem-solving, the second competency, requires leaders to consider a variety of factors including time constraints, the short- and long-term goals of the organisation and external issues, among others, which all affect the solutions to organisational challenges (Mumford, et al., 2000: 15). Problem-solving is seen as a 'puzzle' which leaders effectively solve by identifying the extent of the organisational problem, gathering information, teaching and informing stakeholders about the problem, developing possible solutions and lastly carefully implementing and executing the best solution. The Skills Model views problem-solving skills as essential for a leader to have effective performance.

Social judgement skills are also seen as an important competency for effective performance of leaders in the Skills Model (Mumford, et al., 2000). Social judgement here is viewed in parallel to 'human skills' which is outlined in the Skills Approach by Katz (1955, cited in Northouse, 2016). Social skills are defined as the ability of a leader to work effectively with others using skills which include "perspective taking, social perceptiveness, behavioural flexibility and social performance" (Northouse, 2016: 49).

Perspective taking refers to the empathic side of the problem-solving process where the views and attitudes of others towards a problem are considered (Zaccaro, et al., 1991, cited in Northouse, 2016: 49). Further, perspective taking is likened to social intelligence and an understanding of how different members of an organisation would feel about particular problems and potential solutions. Social perceptiveness is described as the insight and awareness of the needs, goals and demands of all the stakeholders of the organisation by the leader (Zaccaro, et al.,1991, cited in Northouse, 2016: 50). Further, it is thought that a leader's social perceptiveness keeps the leader in touch with followers at most times. Behavioural flexibility is described as a leader reacting towards others with flexibility (Zaccaro, et al.,1991, cited in Northouse, 2016). It refers to a leader's ability and understanding to adapt his or her behaviour with an open and accommodating attitude. Social performance is viewed as a number of important competencies for leadership including a leader's ability to understand the perspective of followers, the ability to communicate his or her vision, and skill to persuade change, resolve conflict and function as mediators.

The third competency highlighted by the Skills Model is that of knowledge. Knowledge, when viewed as a competency, is directly related to the "leader's capacity to define complex organisational problems and to attempt to solve them", (Mumford, et al., 2000, cited in Northouse, 2016: 51). Knowledge is more specifically defined as the "accumulation of information and the mental structures used to organise that information" (Northouse, 2016: 51). The more knowledge and organisational structures for that knowledge a person possesses, the more likely that person is to be referred to as an 'expert' on the topic. Northouse (2016) explains that leaders who are knowledgeable have mental structures to organise facts regarding the organisation based on knowledge of products, tasks, people and other aspects of the organisation's activities. This knowledge is seen to have an impact on the leader's ability to engage in problem-solving by their ability to think about 'complex system issues' and to identify strategies for improvement. Knowledge is also seen as the use of historical information to constructively deal with future performance.

2.4.2.3 Leadership Outcomes

The third component of the Skills Model is related to the problem-solving and effective performance of a leader, which is termed 'leadership outcomes'. This resultant component of the model, which is strongly influenced by the leader's competencies, comprises effective problem solving and performance. These two elements are seen to work together and are directly used to assess a leader's effectiveness.

Effective problem solving relates to the reasoning behind why the Skills Model is also referred to as the 'capability model', as explained by Northouse, (2016: 53). The primary capability the model refers to is that of problem-solving, which is assessed by the originality and quality of solutions formulated by a leader. Solutions which are logical, effective and unique and that go beyond given information are seen as good solutions (Mumford, et al., 2000, cited by Northouse, 2016: 53).

The 'performance' element of the leadership outcomes component refers to how a leader has executed his or her job. The evaluation criteria used for leaders is that of annual performance reviews, merit raises, recognition by supervisors and followers for good leadership. Northouse (2016: 54) ultimately states that leadership performance is measured by the degree to which a leader has effectively carried out his or her assigned duties.

2.4.2.4 Career Experiences and Environmental Influences

The remaining components of the Skills Model, according to Mumford, et al. (2000), which relates to the effective performance of leaders, is that of 'career experiences' and 'environmental influences'. Northouse (2016: 54) suggests that career experience has an effect on the attributes and competencies of a leader. The forms of experience emphasised by Mumford, et al. (2000), which they believe are helpful to a leader's development, take the form of challenging work, mentoring, training and personal involvement, and practice in problem solving. In addition to career experience being able to increase knowledge and problem-solving skills (competencies), it is also seen to have the potential to enhance individual attributes or characteristics such as motivation and intellectual ability. Mumford, et al. (2000) and Northouse (2016: 54-55) highlight that leaders develop their conceptual skills, which are crucial at upper management level, over a period of time through engaging in relevant experiences. As such, leadership is seen to be acquired and not in-born.

Environmental influences, according to Northouse (2016: 55) refer to both internal and external factors of the organisation which affect the leader's performance. The internal aspects include factors such as the organisation's technology and facilities, the expertise of subordinates and the organisation's internal and external communication. The constraints attached with these internal factors may affect the way in which problem-solving takes place. External environmental influences include aspects such as economics, politics, social considerations and natural disasters. These aspects are seen to be largely out of the control of the leader, yet it is important for the leader to respond to these challenges for the progress of the organisation (Northouse, 2016).

2.4.3 Leadership Dimensions

Leadership dimensions which relate to leadership excellence are explored by Selvarajah and Meyer (2008). The authors suggest that the standard definition of excellence in leadership is one where a leader surpasses others in accomplishment or achievement. Four dimensions in particular which relate to leadership excellence in terms of a leader's behaviour are personal qualities, managerial behaviour, organisational demands and environmental influences (Selvarajah & Meyer, 2008: 359-360). The authors cite earlier work by Selvarajah, et al. (1995: 39-42) which explains these leadership dimensions, at times referred to as categories. Personal qualities refer to a leader's individual values, skills, attitudes, behaviour and qualities. It comprises the leader's morality, interpersonal relationships and communication. Managerial behaviour refers to the leader's 'persuasive powers' and includes their nature, values, attitudes, actions and styles while performing managerial duties. Organisational demands refer to the leader's focus on the prosperity of the organisation in line with his or her response to goals, objectives, structures and other organisational issues (Selvarajah, et al., 1995, cited in Selvarajah & Meyer, 2008). Lastly, environmental influences refer to the leader's ability to view and understand the external environment of the organisation and to identify opportunities.

Owen (2014: 1), in a handbook of practical skills, explains how a person can learn to lead, and categorises leadership into seven dimensions relating to skills and behaviour required of a leader. These include the leader's mind-set skills, career skills, people skills, 'moment of truth' skills, daily skills, organisational skills and his or her values and behaviours. The author explains that by having knowledge of these dimensions and associated skills an individual is able to better learn leadership through experience. These skill areas are summarised in Table 2.3 below. Knowledge and understanding of the relevant skills are viewed by Owen (2014) as important to a leader so that strengths may be capitalised on and weaknesses may be identified and improved on.

Table 2.3: Areas of leadership skills and behaviours

Leadership category	Leader's developed skill/behaviour
Mind-set Skills	Positivity; responsibility; high aspirations; courage; adaptability; practice, persistence, preparation and a positive outlook; managing stress; honesty; self-awareness; working to win
Career Skills	Understand one's self, others, how one affects others, and the leadership journey; discover one's rules of success; build one's career
People Skills	Delegating; motivating; selling; coaching; managing upwards; flattery; managing professionals
Moment of Truth Skills	Say no; conflict management; crisis management; dealing with difficult bullies; negative feedback; hearing feedback; fighting battles; power; managing adversity
Daily Skills	Reading; writing; presenting; storytelling; listening; numeracy; problem solving; time management
Organisational Skills	Decision making in uncertainty; influencing decisions; negotiations; networking; effective meetings; projects; managing budgets; dealing with advertising; managing change; reorganising; creating a vision
Value and Behaviour	Becoming a leader people want to follow; take control; professional leadership; etiquette; living the values; ambition; hard work; learning to lead

Source: Owen, 2014: 1.

2.5 Professional Registration with ECSA and Engineering Leadership

ECSA and its associated Candidate Academy state that according to the Engineering Profession Act (EPA), 2000 (No. 46 of 2000) all engineering practitioners within South Africa (SA) are to be assessed and registered by the council (Candidate Academy, 2013: 2; ECSA, 2018b). ECSA acts as a statutory body to assure the quality of engineering in infrastructure and industry. The intention of the regulation is to ensure that international standards of work and global recognition of local engineers are maintained (ECSA, 2018c). There are several benefits of an individual registering as a professional engineer with ECSA including peer recognition, public confidence, membership with voluntary associations, international recognition, marketability, exclusive use of reserved names and statutory empowerment (ECSA, 2018d).

It can also be argued that the leadership potential of an individual may increase as a result of registration with ECSA. Northouse (2016: 10) suggests that leadership exists when an individual is able to use ‘power’ to influence others. This power is described as the potential and capacity to influence, and comprises six power bases. These power bases are further classified into two types of power, namely position power and personal power. Position power consists of legitimate, reward, coercive and information power. Personal power comprises reverent and expert power. It is apparent that being a registered professional engineer with ECSA may increase an individual’s leadership ability directly in terms of improving his or her expert, legitimate and information powers. Here expert power is based on followers recognising a leader’s knowledge and skill within the field of engineering. Legitimate power arises from a member who is registered with ECSA having a status and formal appointment with specific authority over work and staff. Information power refers to the engineer probably being higher up in the corporate or project hierarchy and possessing information which others may desire to have, such as the company or project details.

ECSA is also responsible for the accreditation of engineering education and training across the engineering disciplines (ECSA, 2018d), including the accreditation of any ELE which may already be seen as international best practice. The role of ECSA in

ELE and how it relates to leadership competency will be discussed in the sections to follow.

2.5.1 Role of ECSA in Engineering Leadership Education

According to ECSA (2018e) the council's mission largely involves the determination of 'standards for education' and the 'accreditation of educational programmes'. This is in addition to registering engineering practitioners and developing and sustaining a relevant, competent, and internationally recognised engineering profession in SA.

The council states that consideration regarding its accreditation of educational programmes arises from the registration requirements of professional engineers (ECSA, 2018f). ECSA, together with the Council of Higher Education (CHE), is formally mandated in terms of the EPA to ensure critical engineering educational requirements are met. These requirements include the accreditation of engineering programmes which are offered by the CHE. This is to establish and maintain international recognition agreements regarding educational accreditations. These ECSA accredited programmes are recognised by the signatories of international education agreements which include the Washington Accord, Sydney Accord and Dublin Accord (ECSA, 2018g).

In this regard ECSA is responsible for the on-going acknowledgement and promotion of international best practices with regard to educational engineering programmes within SA. ELE is viewed as such an example for consideration locally as it is increasingly included in programmes internationally.

2.5.2 ECSA's Registration Requirements and Leadership Competency

ECSA outlines the requirements for professional registration as an engineer over a series of registration guideline documents. The initial and central document published in 2012 is termed the 'Competency Standards for Registration as a Professional Engineer'. The specific competence and outcomes at relevant levels of performance are outlined for professional engineers in this document and its subsequent ‘Guide to the Competency Standards for Registration as a Professional Engineer’ (ECSA, 2018a).

The competency of a professional engineer is viewed in terms of the possession of knowledge, skills and attributes necessary to perform relevant activities to a standard expected in practice (ECSA, 2018a: 3). The knowledge component of competency is that which is received during the engineering education phase in combination with subsequent engineering work experience (ECSA, 2018a: 3). The remaining components of competency relating to skills and attitudes refer to other developed and accessible outcomes. These components of competency are required to be demonstrated through engineering activities by the integrated performance of the different outcomes, at suitable levels of proficiency. As such, outcomes are seen as a result of demonstration of competence at a required level of performance.

ECSA (2018a: 4) outlines five focal groups in which the eleven required outcomes which must be demonstrated by candidate engineers for professional registration reside. Leadership competency is narrowly included in ‘Group B – Managing Engineering Activities’ which comprises Outcome 4 (Managing part or all of one or more complex engineering activity) and Outcome 5 (Communicating clearly with others in the course of the engineering activity) (ECSA, 2018)

ECSA (2012: 2-3) asserts that Outcome 4 involves the planning, organising, leading and controlling of engineering activities. Here ‘activities’ refer to a range of engineering aspects from design to construction to various others, which involves the oversight of other individuals over and above performing technical functions. The ability to demonstrate ‘leadership’ is specifically required here, with the engineer being able to ‘control’ in a team context. Outcome 5 relating to technical communication is viewed in parallel to the previously mentioned requirement and supports the engineering solution from analysis to implementation. Important to note is that the ECSA requirements here expand not only to require the oral and written communication to relate to technical matters but also “financial, social, cultural, environmental and political aspects” (ECSA, 2018a: 15). Further, engineers must be able to “manage self, work effectively in a team, manage people, work priorities, work process and resources” and “establish and maintain professional and business relationships” (ECSA, 2018a: 15). These requirements are thought to tie in with the fundamental dimensions of leadership, yet are viewed apart.

Leadership competency is more obligatory and comprehensively described at this level of professional registration guidelines by the ASCE than by ECSA. The ASCE views leadership as one of its specific outcomes, which is well-detailed and elaborated, while ECSA explains its requirement of leadership to be a competency within a management role.

The Candidate Academy (2013: 13-50) registration guidelines allow a link to be made from a real-world challenge to an Engineering Leadership opportunity. This allows for a holistic view of the ECSA leadership competency registration requirement. Figure 2.2 below shows a summarised illustration of where leadership competency is described in this regard. The Engineering Life Cycle (ELC) is seen to originate from the recognition of an existing world problem requiring an engineering solution. The ELC consists of stages including problem-solving, implementation and maintenance of a solution. An engineer is expected to demonstrate technical cross-cutting and enabling competencies which result in the outcomes being achieved. Here outcomes are viewed as a conclusion reached through logical thinking (Candidate Academy, 2013: 13-14). Enabling competencies of an engineer are seen to comprise professional, personal and ethical competencies which are viewed as how an engineer conducts themselves and makes decisions (Candidate Academy, 2013: 26).

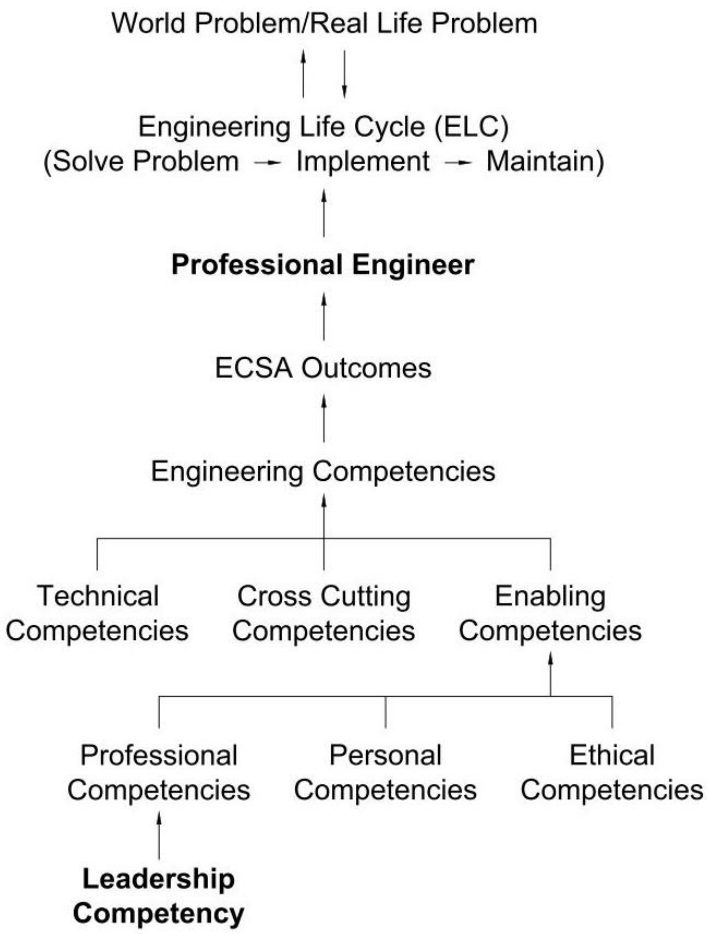


Figure 2.2: Summarised illustration of where Leadership is positioned as a professional registration requirement by ECSA

Source: Author.

Professional competencies comprise communication, collaboration, problem-solving, management and business practice. Leadership competency is highlighted early in the list of management and business practices among other skills such as delegation, following-up, time management, stress management, decision-making, and so forth.

2.5.3 Present Leadership Development Circumstances in South Africa

The current South African engineering tertiary education curriculums are not structured to explicitly develop leadership competency (knowledge, skills and attributes) in graduate engineers. The Candidate Academy's (2013: 27) registration guide explains where the present ECSA registration model expects the development of these ‘enabling competencies’ to occur. Leadership is expected to be developed as an engineer takes on more management duties, post-graduation, through work experience. The Candidate Academy (2013) also mentions that some amount of competency may be enhanced by attending courses, however it is suggested that competency is better developed in the workplace. Workplace development is anticipated to take place through coaching, shadowing, observation and practice. It is proposed that candidates should pay special attention to how mentors or supervisors with experience deal with interpersonal situations regarding clients, government officials and staff members (Candidate Academy, 2013: 27).

2.5.4 Minimum Requirements of Leadership Competency for Registration

The work experience of a candidate engineer is judged to determine if the various required outcomes have been achieved for professional registration. This includes the demonstration of Group B outcomes (Managing Engineering Activities), under which leadership competency is a requirement. ECSA (2018a: 6) provides a definition of the demands and responsibilities required of a candidate to meet the competency standard for professional registration. ECSA (2012: 1) specifies that complex engineering activities must be undertaken where integration of the outcomes takes place at specified levels of performance. Complex engineering activities are broken down into scope, context, resources, interaction, constraints, risks and consequences of the activity in which an engineer is involved. The engineering activities described extend through all aspects of the engineering life cycle from concept design to commercialisation or construction, and so forth.

The outcome group under which the leadership competency standard is outlined requires a candidate to manage part of or all complex engineering activities, to achieve engineering results through the management of people, among other aspects. It is further thought to involve communicating clearly with others during the course of these engineering activities. This communication is said to involve the strategic, managerial and technical aspects of engineering work. The intended communication is expected to involve peers, supervisors, construction contractors, personnel from other disciplines of the project, clients and other stakeholders. This communication is expected to be performed reliably and repeatedly (ECSA, 2012: 3).

It emerges that while components of leadership competency are mentioned in the assessment criteria for professional registration there is still a lack of correlation and explicit demand for theoretically defined leadership competency. Further it is noted that while ECSA's guide to the competency standards (ECSA, 2018a) and the Candidate Academy's registration guide (Candidate Academy, 2013) explicitly mention 'leadership' competency as a requirement, the competency standards document (ECSA, 2012) does not, which could be the reason for the lack of emphasis on leadership competency as a professional registration requirement.

2.5.5 Shortfalls of Leadership Development by Current Approach

As previously mentioned, the definition of 'competency' by ECSA (2018: 3) for professional engineers refers to the possession of the "necessary knowledge, skills and attributes to perform activities to a required standard". Therefore, it may be argued that the present leadership development approach of observation and self-development through, predominantly, work experience does not allow for the 'knowledge' component of leadership competency to be developed efficiently and effectively. This is in contrast to technical competencies which are at present prioritised at tertiary institutions and then further developed during subsequent work experience. This suggests that leadership development should also be formally included and given priority within the tertiary engineering education curriculum.

Of specific concern is where a lack of knowledgeable mentorship with regards to leadership competency is available to a graduate engineer. Leadership is explained to be a diverse and important area of competence to a professional engineer, which extends beyond the gains that they may effectively receive by general observation and experience. Owen (2014: 1) highlights this concern when he states that "the problem with learning [leadership] from experience is that it is a random walk". This implies that it is completely dependent on an individual's fortune that a good role model and work experience would occur which would result in good lessons learnt; however it is just as likely that the opposite could occur and an engineer would thus not receive adequate mentorship and would therefore not develop the required leadership competency.

Paul and Falls (2015a: 1) stress the view that while engineering graduates are well educated in technical aspects of engineering, they “lack qualities such as communication, self-management, problem solving, creativity as well as management and leadership competencies”. This absence of preparation in leadership competencies, according to Paul and Falls (2015a) hinders innovation in the engineering field. Similarly, Sidhu (2015) asserts that a failure to address the need for leadership development at a foundational level in engineers within an increasingly competitive global society could have various negative consequences for the local graduating engineers and the industry. “Talented technical staff and leading innovators” are seen as a critical source of competitiveness among global firms (Sidhu, 2015: 2). In this respect, higher performing engineers are promoted within such corporations with an expectation that they will perform as both engineers and leaders.

Sidhu (2015) highlights that the need for ELE may have originated from an initial focus on entrepreneurship education. However, he argues that the ability of engineers to begin new initiatives is only a part of the greater leadership role. A lack of leadership in engineering is thought to have consequences including:

1) organisational indecision about new products and services;
2) disagreement between product management and engineering;
3) delayed and halted projects;
4) reduced research and development productivity;
5) poor technology strategies;
6) team morale and retention issues; and
7) an overall poor competitive performance (Sidhu, 2015: 2).

Thus, Sidhu (2015) concludes that, more than just a hindrance of technological innovation, a lack of leadership competency has more diverse negative consequences which can affect an organisation’s performance.

2.6 Engineering Leadership Education (ELE)

It is evident throughout the available literature on the topic of Engineering Leadership that many organisations and individuals have highlighted the increasing demand for leadership development in graduate engineers. Schuhmann (2010: 61) explains that in a rapidly progressing global and technological environment engineers require greatly increased skills training to lead people effectively. Further, this need for Engineering Leadership presents itself in different sectors including business, non-profit and government sectors.

The literature review of best practices shows that international engineering universities have over recent years placed considerable emphasis on the development and implementation of ELE programmes. Ahn, et al. (2014: 117) contend that it is imperative to identify the key leadership capabilities required by practicing engineers in order to teach Engineering Leadership in an objective way. Further to this, the authors explain that a lack of predetermined measures of any outlined skills makes it difficult to monitor improvements and effectiveness of leadership programmes. In the section to follow, ELE programmes will be explored in some depth, and the characteristics of successful ELE programmes will be outlined.

2.6.1 Themes, Goals and Objectives of ELE Programmes

Graham, et al. (2009), who carried out one of the most predominant underlining studies about the state of ELE globally, noted that all the established programmes at the time differed from each other. During a review of current programmes it was noted that this dissimilarity still continues in programmes offered worldwide. Institutions with programmes that are well regarded by stakeholders and those viewed as international best practice of ELE consists of varying goals and objectives. These programmes were reviewed and outlined by Crumpton-Young et al. (2010) in both an industry and academic setting, particularly in terms of specific engineering programmes focused on developing leadership in engineers. The goal of most of these programmes is to transition young engineers from an abstract theoretical mind-set to that of a corporate one through training, assignments and career development.

Crumpton-Young, et al. (2010: 10-16) explain that programme objectives of industry leaders in leadership development are generally aimed at improving engineers in areas of their: 1) global understanding of business; 2) skills in current technologies; and 3) ability to solve business challenges. The authors outline the aims of some of these programmes as follows (Crumpton-Young, et al., 2010: 15-16):

- Lockheed Martin’s Leadership Development Programme is designed to teach practical and strategic leadership and interpersonal skills;
- General Electric’s Engineering Leadership development comprises a few programmes. Two important leadership programmes specifically mentioned are the Edison Engineering Development Programme and the Operations Management Leadership Programme. These combined programmes offer training in business, project management, negotiation, career management, business writing and presentation skills;
- BAE Systems (Inc.) Engineering Leadership Development Programme offers educational coursework to improve presentation, teamwork skills, individual leadership and communication style, self-awareness and emotional intelligence, conflict management, and how to effectively lead and motivate team members; and
- National Aeronautics and Space Administration’s (NASA) System Engineering Leadership Development programme offers a detailed view of management areas including marketing, sales, public relations, ethics in engineering, leadership training, human resources, technology, legal, risk management, finance, and politics.

Engineering Leadership programmes offered by academic institutions to engineering students, according to Crumpton-Young, et al. (2010: 16-17), focus on leadership and team building prior to entering the work space. The authors outline some of these programmes as follows (Crumpton-Young, et al., 2010):

- Georgia Institute of Technology, Northeastern University and the Massachusetts Institute of Technology, who offer, the Institute for Leadership and Entrepreneurship Program, Gordon Engineering Leadership Program and the Gordon-MIT Engineering Leadership Program, respectively, aim to create skilled, ethical, and visionary leaders. These programmes are classified as compulsory interdisciplinary courses and provide students with development in teamwork, communication, ethics, global and organisational leadership.
- The University of Michigan, Loyola Marymount University and the University of Houston offer the following programmes: Engineering Global Leadership Program, Systems Engineering and Leadership Program and the Engineering Leadership and Entrepreneurism Program, respectively. These programmes aim to create industry leaders by providing education in how to lead in system engineering activities, manage interdisciplinary engineering teams and execute business fundamentals. The programmes require students to complete the traditional engineering curriculum and additional courses which include marketing, accounting, finance, history, economics, a foreign language and political science.
- The University of Kansas offers an 'Engineering and Leadership Program' which aims to improve leadership, managerial, interpersonal, business, entrepreneurial, and engineering skills This is carried out through coursework, with mentoring, workshops and other additional educational leadership opportunities being provided to participating students.
- The Pennsylvania State University offers an 'Engineering Leadership Development Minor' which is aimed at providing students with realistic leadership and project management experience education, in addition to encouraging a positive impact on issues affecting the world. Topics covered in the programme include teamwork, innovation, leadership within an organisation, public policy, ethics, business issues, finance, marketing and investment.
- The University of Maryland offers an Engineering Leadership minor which concentrates on communication, global awareness, project management and understanding oneself and working effectively with others The programme incorporates mentoring, networking and leadership opportunities within the campus and community to actively develop leadership.

- The University of Central Florida offers an ‘Engineering Leadership and Management Minor’ which aims to provide a basic understanding of project engineering, administration, team effectiveness and financial engineering for all undergraduate engineers via coursework. The coursework is supported with experimental learning activities which concentrate on Engineering Leadership principles and practices. They are specifically developed to improve ethical engineering practice, negotiation and interpersonal skills of young engineers.

2.6.2 Approaches to ELE by Well-recognised Programmes

Hartmann (2016: 18) acknowledges that while globally a major shortfall of ELE implementation in universities continues to exist, some pioneering institutions have successfully developed and implemented leadership programmes, minors and certificates to meet the demand. Crumpton-Young, et al. (2010: 16) explain that most ELE delivered at universities comprises individual courses or certificate programmes in leadership. Further, the authors indicate that the approaches to leadership development that they investigated often include coursework, team projects and industry experience.

Graham, et al. (2009: 14) state that ELE programmes can be seen to have an explicit or non-explicit approach. An explicit approach is one where the primary focus of any implemented programme is to develop Engineering Leadership characteristics. A non-explicit approach, on the other hand, is one where leadership development is incorporated into other programmes which have their own primary objectives.

Some highly regarded programmes with explicit approaches to ELE were reviewed by Graham, et al. (2009: 17-27) and include:

- Penn State University’s optional Engineering Leadership Development minor (ELDM). The focus of the programme is on business, personal and global leadership development and occurs via class discussions, international travel and contextual learning. Leadership theory and skills, knowledge of the world, cross-cultural communication and participation in change processes are important parts of the programme. The programme structure comprises compulsory core modules including Leadership Principles, Leadership Practicum and Technology Based Entrepreneurship. Additional credits to complete the programme are gained by completing either the ‘global option’ route or further individual modules. The global option route sees students attend seminars, complete projects and travel abroad to predetermined countries to participate in Leadership, Innovation and Global Resource challenges. The alternate route comprises two additional modules, namely Leadership in Organisations and Science Technology and Public Policy.

- The Iowa State University’s (ISU) co-curricular Engineering Leadership Program (ELP) is offered to a selected small group of students. The programme extends throughout the students’ undergraduate studies and focuses on developing engineers towards taking on more leadership roles and working towards a better society. Particular outcomes through which leadership competencies are outlined and assessed include the demonstration of leadership characteristics, engaging others, awareness and growth, and demonstrating excellence. These themes are further elaborated in Table 2.4 below.

Table 2.4: Themes and competencies of the ISU’s ELP

Theme within programme	Competency developed and assessed
Leadership characteristic	Initiative; integrity; analysis and judgement; communication; energy and drive
Engaging others	Building a successful team; developing others; coaching; teamwork; leading through vision and values
Awareness and growth	Engineering knowledge; general knowledge; cultural adaptability; continuous learning
Demonstration of excellence	Quality orientation, customer focus, innovation, professional impact, planning

Source: Graham, et al., 2009: 21-22.

The authors further explain that the desired competencies developed through the ELP are fostered and proved through a wide structured approach, extending throughout the student’s undergraduate programme. The programme approach comprises leadership retreats, seminars, mentoring programmes, learning projects, reflection journals and personal portfolios. Further explanation of these activities follows in Table 2.5 below.

Table 2.5: Approach of the ISU's ELP

Activity within programme	**Competency developed and assessed**
Leadership and community retreats	These involve off-campus team and community building events which focus on introducing leadership concepts and connecting peer groups
Leadership seminars	These involve weekly seminars held by students and external speakers discussing leadership types and skills
Peer and faculty leadership mentoring	Students of the ELP are allocated more senior mentors from the programme and faculty mentors to assist with the leadership development and support of new entrants
Leadership learning projects	This entails a service-learning project in the early phase of the programme which allows students to develop leadership skills through a positive community project. In subsequent years of the programme students propose their own projects for their personal development and contribution to the community
Reflection journals and a personal leadership portfolio	First year students within the ELP compile weekly reflection journals of suggested or personal leadership topics. In subsequent years students compile a portfolio of their leadership development by tracking and reflecting on themes and specific competencies previously mentioned in Table 2.4

Source: Graham, et al., 2009: 20-21.

- The Massachusetts Institute of Technology's (MIT) Gordon-MIT Engineering Leadership Program (Gordon-MIT ELP) is offered in varying extents to students. At the baseline Graham, et al. (2009: 22-23) explain that all MIT engineering students gain results-orientated leadership experience through project-based learning as part of the normal academic fulfilment. Furthermore, the Gordon-MIT ELP which is offered to fewer engineering students makes use of advanced coursework and diverse projects to develop leadership skills and further allow students the ability to direct the leadership programme. The focus of the programme is to develop engineers who are innovative and able to implement engineering tasks effectively. The central aim of the programme, which works around a framework of recurring phases of theory, application and reflection, is to give undergraduate engineers opportunities for leadership development. The methods of achieving the desired leadership development takes place through leadership courses, leadership application through project-based experiences, staff and industry mentoring, and students' continuous reflection on their personal leadership plan. More specifically, according to Graham, et al. (2009: 24), the Gordon Engineering Leaders (GELs) engage in weekly 'Engineering Leadership Labs' which simulate real life leadership scenarios centred on the mentioned aspects of theory, application and reflection.

  The 'theory' component entails the student's selection of four short leadership subjects and one advanced subject. The 'application' component involves the completion of two scale projects and industry vacation work to practice and be exposed to leadership. In addition, the application component involves the GELs becoming responsible for the leadership programme itself in terms of design and delivery, as well as becoming leadership coaches to junior students. Lastly, the 'reflection' component of the programme requires students to create a personal leadership development plan and thereafter evaluate their progress with the programme's mentors (Graham, et al, 2009: 24).

- Monash University's co-curricular Leadership in a Technological Environment programme is a three-year structured leadership programme that aims to attract top performing engineering students in addition to addressing industry needs.

The programme is offered to a select high achieving and/or motivated group of students who demonstrate high leadership potential and desire.

The programme's approach is structured around coursework, workshops and industry experience. Table 2.6 summarises more specifically the activities undertaken within the programme to develop leadership in students.

Table 2.6: Approach of Monash University's Leadership in a Technology Environment programme

Activity within programme	**Competency developed and assessed**
Leadership workshops	The programme begins with an intensive foundational workshop which aims to create leadership awareness, community connection and preparation for the programme ahead. Activities such as determining one's personality type and the associated leadership approaches that accompany it are explored.
Leadership modules	These involve the completion of nine short modules over the three-year programme in topics of leadership, ethics and change management. Modules are presented by experts, assessed through team activities or projects and lastly, discussed and reflected on with a panel from industry.
Industry leadership experience	Work experience forms a requirement of the leadership development process where the time respondents spend shadowing leaders within the industry is built up from as early as first year.
Networking opportunities	The programme deliberately incorporates networking events which expose students to industry and university leaders in an informal setting.

Source: Graham, et al., 2009: 25-27.

2.7 Conclusion

The review of literature covered various topics and considerations regarding ELE and any future implementation locally. As such, the chapter was structured around general leadership and Engineering Leadership theory, frameworks of existing ELE programmes and the current requirements and role of ECSA with regards to ELE. The literature revealed that Engineering Leadership is recognised as important to give vision to a country and shape public policy. More directly, the engineering profession is vital for the health, safety and development of a country. Engineering Leadership is required in SA for solving complex challenges through innovation. Influential leadership required to achieve shared goals based on Engineering Leadership principles, responsibilities and competencies are crucial and give a country a competitive advantage. Leadership theory including the Skills Approach supports the notion that leadership can be taught and learned and leadership competency (knowledge, skills and attributes) can be developed in engineers at a foundational level.

ECSA was identified as the primary authority responsible for the accreditation of engineering education programmes and training, as well as the registration of engineers and monitoring of their sustained development. While leadership competency is recognised by the council as necessary for professional registration, its guidelines and enforcement are not comparable to international best practice, resulting in ELE being overlooked in SA. The need to develop coherent leadership programmes which are objective and able to be monitored and improved dictates that work needs to be done locally to introduce and entrench ELE.

Existing ELE programmes were reviewed and found to have varying goals, objectives, themes and approaches. The level of implementation and forms of accreditation also varies across even explicitly implemented ELE programmes. It was therefore important to explore many frameworks in this study in order to develop a research instrument to test and measure the preferences of the local engineering industry to determine what form of ELE would be widely appreciated in SA. The following chapter outlines the research strategy and design implemented to derive recommendations in this regard.

CHAPTER THREE
Research Methodology

3.1 Introduction

The previous chapters set out the purpose and objectives of the study and provided a review of the literature related to the research topic. This chapter discusses how the research was conducted to achieve those objectives and, more specifically, outlines the procedures and techniques that were employed to ensure that overall good quality results were achieved. The chapter introduces the research paradigm and philosophy on which the study is theoretically grounded. Subsequently, the research design section delineates the considerations taken into account regarding the strategy of data collection and interpretation that was required. The study setting and target population are elaborated on and details regarding sampling and the methods employed are provided. A discussion and explanation regarding the development and the testing of the measurement instrument used in the study is also reported. The factors related to the mitigation of risk to the reliability and validity of the research are outlined in detail. Further, considerations regarding bias are addressed. Lastly, the ethical considerations impacting on the study are discussed and details regarding the researcher's conduct to maintain the integrity of the study, in terms of ethical duties and relevant approvals, are provided.

3.2 Aim and Objectives of the Study

The aim of the research was to determine ECSA members' preferred framework for ELE within South African tertiary education institutions, based on international best practice.

The following research objectives guided the study:

3.2.1 To identify what is meant by 'leadership' competency as a requirement for professional registration of engineers, by ECSA.

3.2.2 To identify what dimensions of leadership competency are delivered through international best practice of ELE.

3.2.3 To determine what the perceived current level of leadership capabilities (or gaps) is in present graduate engineers from South African tertiary institutions, by members of ECSA.

3.2.4 To determine what the consensus is among the ECSA membership about any possible implementation of ELE within South African tertiary institutions.

3.2.5 To formulate and recommend ECSA members' preferred framework of ELE based on international best practice, which could be implemented in South African tertiary institutions.

3.3 Research Paradigm

The nature of the research carried out in this study was that of a fundamental research type, as described by Saunders, Lewis and Thornhill (2016: 9-10). Fundamental research aims to increase knowledge of a phenomenon. It is expected to increase the general understanding of the principles relating to the phenomenon, explain relationships of phenomenon to outcomes and lastly, relate findings of value to society.

Saunders, et al. (2016: 132) describe the research paradigm as a set of basic assumptions which provide a 'lens' through which to view a topic and suggests ways of theorising it. This study tended towards a functionalist paradigm, which focused the research towards the dimensions of objectivism and regulation. The authors describe this type of research to be of a rational nature which develops recommendations for working within the current organisational structures.

The research philosophy is referred to as the beliefs and assumptions used when developing knowledge, as explained by Saunders, et al. (2016: 124). This research began with the identification of a problem, that is, a lack of formal Engineering Leadership development in SA. As such, the research was carried out with the aim of offering a preferred solution which could inform future education, training and practice in the South African context. This research philosophy is described by Saunders, et al. (2016: 142-143) as a pragmatic approach. In this approach the most important factor of the research strategy is to address the research questions, which in turn offer practical outcomes.

3.4 Research Design and Methods

The research design refers to the overall strategy adopted for a particular study (Leedy & Ormrod, 2013: 74). It is the planning and structuring undertaken with regards to the research procedures and issues that may be encountered. The research design involves all the considerations around the availability of data, data collection and data interpretation, to answer the central research questions. Saunders, et al. (2016: 162-165) provide a similar description and explain the research design as a general plan to answer the research questions. The authors assert that this part of the research, from the research philosophy and approach to theory development, may be viewed as the research process. This process encompasses the methodological choice, research strategy and research time horizon.

Based on the research paradigm established in this study, the methodological choice adopted was that of a ‘mono method quantitative approach’, explained by Saunders, et al. (2016: 166) as an approach where only a single method is used. A descriptive, survey strategy was used in this study to collect data via a questionnaire instrument and results were numerically analysed. Saunders, et al. (2016: 165) highlight that a descriptive study is one which is capable of gaining an accurate profile of people or situations. In the case of this study the characteristics of ELE, as they are implemented internationally, were tested in a local context. Leedy and Ormrod (2013: 189, 191) and Creswell (2014: 13) argue that a descriptive approach allows one to gain a measureable account of a population’s attitudes or opinions regarding a topic at a cross-sectional time frame, which may be generalised from an appropriate surveyed sample to the whole population.

Saunders, et al. (2016: 200) suggest that most survey research is carried out during a short time frame, as was the case in this study, and thus yields cross-sectional results which provide a depiction of the phenomenon at a particular time. Additional benefits of carrying out survey research include: having more control over research proceedings; the ability to statistically generalise the findings across the entire population from an adequate sample; and a lower cost of research by carrying out research on a sample in comparison to the whole population (Saunders, et al., 2016: 182). The data type analysed in this study was of measurement scales and statistical interpretation was carried out.

This study took a deductive approach to theory development by making use of existing academic and other related literature to inform the development of a research strategy which was then used to examine the opinions and attitudes of the surveyed population. This is line with Saunders', et al. (2016: 146) view of a deductive approach, where an existing theory or framework is tested through the research process. Literature relating to the specific ELE programmes of various international engineering institutions was reviewed at the outset of this study. This review of the existing frameworks (ELE programmes) made it possible to predetermine questions regarding the research topic, to which respondents indicated their responses in terms of their preferences, based on international best practice. No appropriate instrument to elicit the required information existed prior to this, thus a new questionnaire was developed.

3.5 Study Setting and Target Population

SA is regarded as one of the most industrialised countries in Africa (Africa.com, 2018). Further, SA is the only country in Africa which is a member of the International Engineering Alliance (IEA) via its principal statutory body, ECSA (ECSA, 2017). ECSA (2017: 2) emphasises that this recognition affirms that SA will continue to conform to "global engineering education competency standards", such that registered members may maintain international accreditation to practice both locally and abroad.

In order to determine the general consensus around Engineering Leadership and any future ELE in SA, a national multidisciplinary survey of engineering practitioners had to be carried out in this study. ECSA's experienced engineering membership was seen as a credible target population to gain such insight. ECSA comprises and regulates the majority of engineering disciplines in SA including aeronautical, agricultural, civil, chemical, computer, electrical, electronic, industrial and mechanical engineering (ECSA, 2018h). By law, all local engineering practitioners of these disciplines must be registered with ECSA to be professionally recognised. Further, ECSA's responsibility to set out the minimum engineering education requirements for South African tertiary institutions and accredit such programmes for professional registration confirms the council as being directly of import to the research topic. Thus, the study was seen as an opportunity to gain industry insight which could inform future decisions of ECSA with regard to ELE. Other stakeholders of ELE which would make up the general population affected by the research outcomes, who were however not targeted in their capacity, included the Department of Higher Education and Training, engineering students, engineering employers and engineering clients, among others.

3.6 Sample and Sampling Method

Due to the large membership of ECSA, wide geographic distribution of respondents, high cost of data collection procedures and extensive time constraints it was not possible to survey the entire target population. Probability sampling was therefore employed which, according to Saunders, et al. (2016: 276-295) is the most commonly used sampling route for a survey research strategy. Probability sampling is a preferable method to establish the sample for a study as it ensures that the chances of any member within the target population being selected are equal, and the statistical analysis of the characteristics of the sample can be considered to be representative of the entire population. The results were not inferred for any other group or stakeholders outside of the target population, the ECSA membership, as advised by Saunders, et al. (2016: 278). The sample frame, which is described as a complete membership list of up to date, statistically accurate data (Saunders, et al. 2016: 277) was derived from ECSA's latest available annual report published in 2018. The categories of membership of ECSA's total registered members for the period 2017-2018 are presented in Table 3.1 below.

Table 3.1: Summary of ECSA membership statistics for 2017-2018

Category of Membership	**Total Registered Members**
Professional Engineer	17226
Professional Engineering Technologist	5706
Professional Certificated Engineer	983
Professional Engineering Technician	5159
Registered Lifting Machinery Inspector	978
Registered Medical Equipment Maintainer	3
Registered Fire Protection Systems Inspector	0
Registered Lift Inspector	108
Candidate Engineer	10084
Candidate Engineering Technologist	4881
Candidate Certificated Engineer	306
Candidate Engineering Technician	7123
Total Registered Persons	*52557*

Source: ECSA, 2018i: 89-93.

The data collection method used in this study was that of a voluntary online survey distributed to all contactable ECSA members via their respective engineering associations. The desired sample size was estimated at the outset of the study in order to determine at what point data collection could cease. Saunders, et al. (2016: 279) define the statistical confidence level of data collected from a sample to be the "level of certainty to which it represents the total target population". For this study a 95% confidence interval was decided to be satisfactory. This is deemed to be acceptable according to Saunders, et al. (2016: 280) who propose that most business and management research is sufficient with a 95% confidence level, with a 3 to 5% variance from true responses.

The results were assumed to follow a normal distribution and the Central Limit Theorem was utilised to carry out statistical inferences. The statistical table by Saunders', et al. (2016: 281) based on the mentioned distribution assumption was used to calculate the required sample size. The value was interpolated to be a minimum of 376 responses across the total target population of 52 557 members.

This approximation was based on a corresponding 5% margin of error. It was noted that the minimum sample sizes to achieve more specific results in terms of the various registration categories of professional, specialist and candidate engineers were equally onerous. As such a decision to not limit the survey to experienced professionals' opinions only was taken. Table 3.2 below shows the required sample sizes for each category, had such an approach been taken.

Table 3.2: Summary of sample sizes required for 95% confidence level

Registration Category	Total Members	Sample Size Required
Professionals	29074	373
Specialists	1089	281
Candidates	22394	371
Total Membership	**52557**	**376**

Source : Author.

The specific sampling technique used in this study for the probability sample design can best be described as that of simple random selection, as no specific respondents were directly pursued. The survey was distributed across as many local engineering associations as possible, to which the target population belonged. Random ECSA members volunteered to participate upon receiving the invitation to participate from their respective associations. Table 3.3 below outlines the recognised local engineering associations from ECSA's website (ECSA, 2018h) who were contactable and positively responded by distributing the research survey invite to their memberships. Leedy and Ormrod (2013: 207) explain that simple random selection technique is valid because it offers every part of the target population an equal chance to participate.

Table 3.3: Engineering associations that distributed the survey

Recognised Engineering Association by ECSA	Date Distributed	Date Closed
Aeronautical Society of South Africa (AeSSA)	21/08/2019	26/09/2019
SA Institute of Electrical Engineers (SAIEE)	02/09/2019	26/09/2019
SA Institute of Civil Engineers (SAICE)	28/08/2019	26/09/2019
SA Institute of Industrial Engineers (SAIIE)	26/08/2019	26/09/2019
SA Institute of Mechanical Engineers (SAIMechE)	09/09/2019	26/09/2019

Source: Author.

3.7 Construction of Measurement Instrument and Data Collection

Leedy and Ormrod (2013: 81-89) explain that in order to precisely answer the research questions it is necessary to capture the research's observations by measuring them. Measurement instruments are seen as the foundation of the problem-solving efforts to research. Leedy and Ormrod (2013) state that measurement types are divided into 'substantial' measures, which are physical entities of measure, or 'insubstantial' measures, which include concepts, ideas, opinions and feelings. The measurement of insubstantial phenomena, such as in this study, may be carried out using nominal, ordinal, interval or ratio scales. Ordinal scales are described to have the properties which allow one to determine one measured item to be more or less than another. interval scales, according to Leedy and Ormrod (2013), and allow a researcher to more specifically determine how many units more or less one item is to another. These scales were utilised in the questionnaire for this study.

In simple terms, according to Leedy and Ormrod (2013: 189), survey research using questionnaires is a process of gaining information about a group of individuals, such as their opinions, by asking respondents questions and collecting their specific responses. Subsequently a process of summarising the responses by determining percentages, frequency counts and other statistical indexes are used to establish deductions about the total target population.

Creswell (2014: 160) suggests that online survey products are increasingly being used to design and execute surveys which also offer the benefits of assembling data, compiling descriptive statistics and producing graphic illustrations. Leedy and Ormrod (2013: 191) add that the benefits of online surveys methods stem from the practical benefits of lower cost and time required to distribute and collect questionnaires. The drawbacks of online questionnaires are identified as lower return rates, limitations around participant's literacy levels and the possibility of general misinterpretation of questions (Leedy & Ormrod, 2013). The need to pay attention to methodological details is emphasised by Leedy and Ormrod (2013) as being important throughout the construction, distribution and collection of the survey.

An online questionnaire was constructed that was based on international best practices of ELE which were reviewed early in this study. The survey was used to measure and collect predominantly insubstantial data including the preferences and opinions of respondents with regard to the research topic. The questionnaire was constructed using an internet-based survey tool, Google Forms. The questionnaire comprised 4 sections which included 103 questions in total. The first section collected the demographic details of the respondents, while the remaining three sections collected the responses required to answer the specific research questions of the study. The questions in the survey were formulated using both nominal and ordinal scale type questions (Appendix 4). Table 3.4 provides a breakdown of the survey instrument's structure and content.

Table 3.4: Structure of research questionnaire

Section	Aspect	Information tested/measured
1	Demographics	Biographical information
		Engineering discipline and experience details
		ECSA registration details
2	Overview of Engineering Leadership competencies	Engineering Leadership responsibilities
		Engineering Leadership principles
		Engineering Leadership qualities and attributes

Section	Aspect	Information tested/measured
3	Perceived level of Engineering Leadership competency in South Africa at present	Awareness of ELE
		Perceived level of ELE knowledge and competence
		Perceived level of specific Engineering Leadership shortfalls
4	Preferred framework for any future ELE in South Africa	Desire for ELE
		Level of ELE implementation
		Aims/goals of ELE
		Themes of ELE
		Specific approaches/methods to ELE

Source: Author.

Recommendations provided by Leedy and Ormrod (2013: 92) were followed to increase the validity of the questionnaire. These included: 1) consulting available literature to see what techniques other researchers have used to effectively measure the phenomena; 2) having the draft versions checked by all relevant and experienced persons; and 3) pilot testing and scrutinising the process and results for weaknesses.

An invitation to participate in the study was emailed to members of local engineering associations which comprise ECSA's membership. These associations consist of all the sub-groups of the target population including candidate engineers, professional engineers and student engineers. Furthermore, the associations covered most of the major engineering disciplines. Attached to the invitation was an 'Information and Consent to Participate' letter (Appendix 3) in PDF format which provided an overview informing respondents of the nature of the research and the aims of the study. The document contained the Google Forms hyperlink to the online survey at the end, for members to participate in the study on a voluntary basis if they wished to. Responses were captured in real time and completed submissions were tabulated by the online survey tool. Data collection was open for a period of five weeks from the time the associations distributed the research information and invitation, to the time it was observed that little to no further responses were being submitted. All data collection took place between August 21 and September 26, 2019. It was not possible to ask ECSA to more directly distribute the survey to its membership via its online membership portal due to policy constraints regarding the use of their membership data base for correspondence other than council communications.

3.8 Analysis of Data

Statistical procedures are described by Leedy and Ormrod (2013: 270) as being a central tool in research to analyse and interpret results in order to uncover the meaning of the research data. Saunders, et al. (2016: 498) explain that there are various aspects to be considered early in the research process for the appropriate analysis of quantitative data, which include: 1) the size of the sample being used; 2) the measurement scales being used; 3) the format, coding and entering of data into any required computer analysis package; 4) any need to weight data for various cases; and 5) the checking of data for errors.

Leedy and Ormrod (2013: 278-282) explain that the nature of data collected affects the statistical procedures which are carried out in a study. The nature of data includes or involves aspects such as: 1) the number of groups from which the data is collected; 2) the type of variables being considered;3) the scales used to measure responses; and 4) the overall distribution of the final data (Leedy & Ormrod, 2013). The extent to which parametric statistics may be carried out is based on the resulting data. Non-parametric statistical analysis yields less comprehensive results but is the only resulting method where ordinal or other non-normal distribution data are presented (Leedy & Ormrod, 2013), as in this study.

Descriptive and inferential statistics were used to answer the core research questions being investigated in this study. The purpose of inferential statistics is described by Leedy and Ormrod (2013: 277) as allowing the data collected from the relatively small sample to be related to the whole target population. This is as opposed to descriptive statistics which are used to describe the specific data collected. Further, the core questions measuring variables of interest in this study were of the ordinal data type, using the five-point Likert-type scales. Leedy and Ormrod (2013: 279) explain that ordinal scales tell of the degree to which the variable being measured is of interest, but not the amount of difference between them. Boone and Boone (2012: 1-4) explore the difference between Likert-type and Likert scale data, and the special consideration for the analysis of each. Likert-type data such as the makeup of this research are explained to be essentially independent questions with no combination of items to form any composite scale (Boone & Boone, 2012).

Jamieson (2017) suggests that some researchers may assume that arithmetic manipulation of verbal statements from their Likert-derived data may offer more meaningful results, comparable to interval scale data analysis. For the purpose of this research additional parametric tests were also utilised to more precisely rank and find associations in the respondents' scoring. The data analysis procedures used in the study are tabulated in Table 3.5 below. The analysis was carried out using the statistical software package SPSS version 26.0. The typical ordinal data are presented in subsequent chapters through the use of pie and bar charts and by tabulation.

Table 3.5: Data analysis procedures appropriate for Likert-Type data

Statistical Procedure	**Method**
Central Tendency	Mean
Variability	Frequencies, standard deviation
Associations	Pearson's chi-square test, Spearman's Rank Order Correlation
Other	Factor analysis, section analysis

Source: Boone & Boone, 2012: 4; Jamieson, 2017.

3.9 Instrument Pre-testing

Carrying out pilot testing of a new instrument to scrutinise it for any weaknesses is imperative (Leedy and Ormrod, 2013: 92). This strategy enhances validity and reliability of the instrument by allowing the researcher to correct or modify the instrument prior to the actual data collection stage. This pre-testing is especially important when insubstantial phenomena such as opinions and feelings are being measured. Leedy and Ormrod (2013: 92) contend that validity of the testing instrument in terms of measuring consistency is crucial and should be checked during pilot testing. This consistency translates to accuracy and is improved through: 1) the standardisation of the survey administration process to respondents; and 2) the reduction of subjective judgements of questions by defining specific criteria which directs judgements of respondents (Leedy & Ormrod, 2013). These measures were adhered to in the study and will be outlined below.

Saunders, et al. (2016: 473-474) advise that a group of experts should be initially consulted to determine the representativeness and suitability of the proposed questions, as well as any additional suggestions. The authors advise that the required size of the pilot test group should be judged on various factors of the particular study. These factors include the types and complexity of the research questions, research objectives, size of the study, as well as any time and financial constraints. Fink (2013, cited in Saunders, et al., 2016: 473) recommends that the pilot group be sufficiently large to determine any major variations, and suggests a minimum of ten respondents for small-scale or student research.

While this particular study involved a relatively large-scale survey the pilot testing was carried out using the minimum requirements due to time constraints. The questionnaire was pretested on ten engineering practitioners stemming from varying engineering disciplines and registration levels within ECSA. The engineers were identified and selected based on their professional registration with ECSA for a period of at least 10 years. Engineers from the researcher’s present and previous places of employment were used. The pre-testing was undertaken to determine whether respondents were able to fully understand and complete answering all questions according to the instructions. Subsequently, the appropriateness and relevance of the questionnaire were judged and discussed.

The approach to the administration of the questionnaire by email was viewed as being a relatively standardised process. During pre-testing some of the questions measuring the value placed on leadership aspects were found to elicit subjective responses from the respondents. The question types were subsequently modified and retested to more specifically and objectively deduce viewpoints of the respondents' personal work experience, to improve descriptions for scoring on interval-like scales and lastly, to add other beneficial demographic questions. Furthermore, specific rating bases were imposed, such as guiding words for judgement and neutral values as scores were done away with on the scales. The questionnaire was subsequently retested and found to be satisfactory.

3.10 Considerations regarding Reliability and Validity

Threats to the validity of research comprise internal and external aspects as well as statistical conclusion errors (Creswell, 2014: 174-180). These factors have the potential to negatively affect the true outcome of an investigation and thus must be eliminated or minimised by researchers. Internal validity concerns are described by Creswell (2014) as those arising directly from: 1) the respondents; 2) the researcher's conduct with regard to the respondents; and 3) the validity regarding the testing experiences of respondents and the instrumentation. External validity concerns in research arise when incorrect correlations or inferences are made from: 1) the sample to the population; 2) the research setting; or 3) past or future occurrences (Creswell, 2014). Statistical conclusion validity concerns arise when incorrect inferences are made from the sample data due to inadequate statistical ability or when incorrect application and execution of statistics occurs (Creswell, 2014). Table 3.6 outlines some of the major concerns identified in this study and explains how these threats to validity where mitigated.

Table 3.6: Identified threats to validity and relevant mitigation

	Description of Risk	Mitigation of Risk
Internal Validity	Extreme scoring may be carried out by respondents for various reasons.	Responses were reviewed and only respondents who displayed considered/ varying answering patterns were considered for analysis.
	Participant selection may be skewed resulting in a portion of the sample being predisposed to particular outcomes.	The study was carried out across engineering disciplines and distributed openly for all to respond. Further, it was carried out on a national platform such that members from all provincial and educational backgrounds/ circumstances could equally participate.
	The questionnaire changes during the pretesting and field data collection period.	The questionnaire was administered unchanged once statistically verified and pilot tested.
External Validity	Only narrow representation of the total stakeholders of the topic is represented by the target population and hence participates.	Claims regarding the research outcome were restricted to the South African engineering industry only. No generalisation outside of this domain took place.
	Research is only specific to a particular setting based on historical and present observations.	The findings of this study are limited to a local context and as such would have to be repeated in any new setting if necessary. The study will have to be repeated at a later stage if circumstances around the topic change.

	Description of Risk	Mitigation of Risk
Statistical Validity	Inaccurate inferences to target population due to inadequate statistical procedures or violating the necessary assumptions.	The questionnaire was approved by a suitably qualified statistician prior to its administration and the data analysis procedures were agreed to be effective. Analysis was carried out using widely accepted analysis software, SPSS, to minimise calculation errors.

Source: Author.

According to Saunders, et al. (2016: 202-207) reliability refers to the ability to replicate a study and its corresponding level of consistency. The ability to repeat a research design and obtain similar results to the original study makes the research more reliable. Consistency comprises internal and external aspects of the research, should a study need to be repeated. Internal reliability refers to the consistency maintained during the execution of the research. External reliability refers to the consistency in the research findings based on the repeated use of the data collection techniques and data analysis procedures. Table 3.7 briefly outlines the main measures implemented in the study to ensure reliability of the findings.

Table 3.7: Identified threats to reliability and relevant mitigation

	Description of Risk	Mitigation of Risk
Internal Reliability	Maintaining consistency through the research process/stages.	The procedures including coding, analysis and interpretation of data were recorded through all stages to ensure a logical and repeatable approach.
	Reliability of the measuring instruments.	Data Science Central (2014) outlines the Cronbach Alpha coefficient check as a widely used statistical check of internal consistency. All relevant items exceeded 0.7 which was viewed as the minimum acceptable for the study. Questions which were not phrased multiple times were reviewed informally to check if answers compared well to each other.
External Reliability	Ensuring data collection and analysis procedures yield consistent results.	The pre-test of the online questionnaire was administered, analysed and interpreted as per the set-out methodology and seen through in the final study, ensuring consistency.

Source: Author.

3.11 Considerations regarding Bias

Bias in research is described by Smith and Nobel (2014: 101-102) as being: 1) a concentration of interest in a specific area of a topic; or 2) a distortion of results due to all factors of a topic not being considered. Bias may be evident across all types of research designs and at different stages of the research processes, negatively impacting validity and reliability of the research. In quantitative design the statistical procedures employed help to reduce bias with respect to sampling and the analysis of data for interpretation. The various types of bias within the research process include design bias, selection and participant bias, data collection and measurement bias, analysis bias and publication bias (Smith & Noble, 2014). Table 3.8 provides a summary of the various measures undertaken in this study to minimise bias where necessary.

Table 3.8: Identified types of research bias and relevant mitigation

	Description of Bias	Mitigation of Risk
Design Bias	Poor choice of research questions and methodology may arise due to the researcher's personal beliefs and an inconsistency between research aims and methods.	Literature regarding the relevant topic was reviewed and only ELE guidelines and programmes which were regarded as international best practice by statutory bodies or peer reviewed papers were used to create the questionnaire to answer the research questions. The research design and execution were carried out using the feedback and approval of peers, academic supervision and the university research ethics committee to provide a robust approach with reduced bias.
Sampling and participation Bias	The process of recruiting respondents and any exclusion may introduce bias to the study.	Recruitment and participation were undertaken independently by means of email and internet distribution to all organisations listed on the ECSA database in addition to internet sourcing, to avoid bias. This approach excluded members without internet, however this minority feedback is not expected to differ based on this communication dissimilarity alone.
Data Collection Bias	Personal beliefs or the way questions are phrased may influence the construction and responses to a newly constructed questionnaire which compromises the validity and reliability of the study.	The newly constructed questionnaire was assessed for any measurement bias and its appropriateness to collect the required and correct information was determined by experienced professional engineers and academic supervisors familiar with the topic.

	Description of Bias	Mitigation of Risk
Data Analysis Bias	A natural tendency of a researcher to pay more attention to data which supports his or her personal beliefs and overlook other data increases bias in the study.	Effort was made to include and assess all qualifying responses uniformly.
Publication Bias	In quantitative studies, statistically significant findings are more likely to be published. In contrast, a weak explanation of research aspects may result in non-publication.	The purpose of the research was set out early and the methodology was comprehensively outlined. The study concentrated on answering the research questions accurately with the survey responses rather than achieving any other consensus.

Source: Author.

3.12 Ethical Considerations

Where research involves human respondents and it has the potential of being physically or physiologically distressing, the ethical implications must be considered carefully (Leedy & Ormrod, 2013: 104-105). The ethical considerations fall into categories which include: 1) the protection of respondents from harm; 2) voluntary and informed participation; 3) the right to privacy; and 4) honesty in reporting findings (Leedy & Ormrod, 2013). Saunders (2016: 249-260) stresses that ethical consideration must occur at all stages of the research including the initial process of obtaining permission and access to potential respondents from the relevant organisation, to the data analysis, reporting and data storage stages.

In order to gain the trust of respondents and to ensure the integrity of the research, ECSA was consulted at the outset of the proposed study. An official gatekeeper's letter (Appendix 1) was obtained allowing the researcher to proceed with the study and data to be collected from the ECSA membership. Further, ethical clearance was applied for and granted (Appendix 2) by the University of KwaZulu-Natal's Research Ethics Committee. Respondents were provided with an information and consent letter (Appendix 3) which provided an outline of the aims and objectives of the study so that they understood the nature of the research and could give their informed consent to participate. Privacy was maintained by making use of Google Cloud storage for responses, and access was restricted to the primary researcher and the research supervisor only. A predetermined university timeline of five years for data storage was adopted, and all data will subsequently be deleted. It was possible to keep the requested personal information of respondents to a superficial and minimal level for this study, thereby ensuring the confidentiality and anonymity of all respondents. In addition, the study was not of a controversial nature which could potentially compromise respondents. All specific personal details are to be kept confidential and unreported in any other publications. Furthermore, the reporting and discussion carried out was based on statistical inference of the sample population and not any individual participant. The surveyed population and other stakeholders have been informed that they may contact the researcher for any required access to the dissertation post approval from the university.

3.13 Conclusion

The research methodology covered in this chapter provides a background to the considerations, planning and strategy undertaken by the researcher in conducting the study. The research was of a fundamental research type with the anticipated aim of increasing the body of knowledge regarding ELE in a local context. The research paradigm adopted was of a rational nature suited to a functionalist paradigm, and was based around objectivism and regulation. The research philosophy adopted for the study was that of a pragmatic approach with the expectation of transforming the data obtained from the research questions into practical outcomes.

The study thus employed a quantitative online survey strategy to measure, analyse and interpret the target population’s opinions and preferences. This approach offered results over a cross-sectional time frame and generalised findings. A new questionnaire was developed and pretested prior to administration. The membership of ECSA was used as the target population for the study and probability sampling was carried out using a simple random selection technique. The core data collected was that of insubstantial measurements which subsequently produced valuable inferential statistics regarding the local engineering industry's preferences for ELE. Specific threats to the validity and reliability of the study comprising internal, external and statistical conclusion aspects were outlined and the mitigation measures implemented in the study were established. Further, specific risks regarding bias which may have taken place at various stages of the research and how these were mitigated were outlined. Lastly, the various ethical considerations for the study, including the acquisition of relevant approvals from stakeholders to guarantee that the integrity of the study was maintained, were summarised. The following chapter presents the results obtained from the execution of the research methodology framed above.

CHAPTER FOUR

Presentation of Results

4.1 Introduction

This chapter presents the findings and analysis of the data obtained from the survey conducted in the study in terms of descriptive and inferential statistics of the target population. The confidence level of the results is addressed to determine the representativeness of the study. Further, the reliability of the results is expressed, based on the Cronbach Alpha standard. The demographics and other descriptive statistics are communicated graphically, through cross tabulations and using other figures. The quantitative raw data gathered to answer the research questions are primarily reviewed descriptively through percentages and means. Thereafter, inferential techniques, which included the use of factor analysis, cross-tabulations and correlations, are investigated and the results are organised in a manner which relates to the research objectives and literature, for assessment and discussion.

4.2 Response Rate, Confidence Level and Margin of Error

In this study, 347 responses were received in total, across all the various local engineering associations that distributed the survey invitation to their membership. Of these, eight (8) responses were discarded as ineligible due to the respondents indicating that they were not members of ECSA, the study's target population. A construed response rate of 90.16% was thus achieved based on the initial target sample size of 376 valid responses. With the 95% confidence level being maintained for the study, the confidence interval was recalculated upward to be 5.31% from the targeted 5.00%.

4.3 Reliability Statistics

The reliability of the survey instrument was based on the Cronbach's Alpha score, calculated by taking several measurements of the same item within its group. A reliability coefficient of 0.7 or higher was considered as adequate. Table 4.1

indicates the reliability score for each item of the questionnaire, as derived from the final valid field data of the study.

Table 4.1: Final Cronbach's Alpha score for survey instrument

Question No.	Sub-section tested	No. of Items	Cronbach's Alpha
2.1	Engineering Leadership Responsibilities	8	0.864
2.2	Engineering Leadership Principles	7	0.859
2.3	Engineering Leadership Qualities and Attributes	15	0.914
3.4	Engineering Leadership Shortfalls	17	0.916
4.3	Aims and Goals of ELE Programmes	16	0.924
4.4	Themes of ELE Programmes	18	0.947
4.5	Approaches to Engineering Leadership Education	9	0.892

Source: Author.

4.4 Descriptive Statistics of Study

The following section graphically illustrates and/or tabulates the processed survey data collected, which is further discussed in subsequent chapters.

4.4.1 Demographics – Biographical Information

4.4.1.1 Age Profile

Figure 4.1 illustrates the percentage and frequency results of a nominal scale question that was used to capture the respondent's age, based on career maturity and experience phases. This is further discussed in section 5.2.3.1.

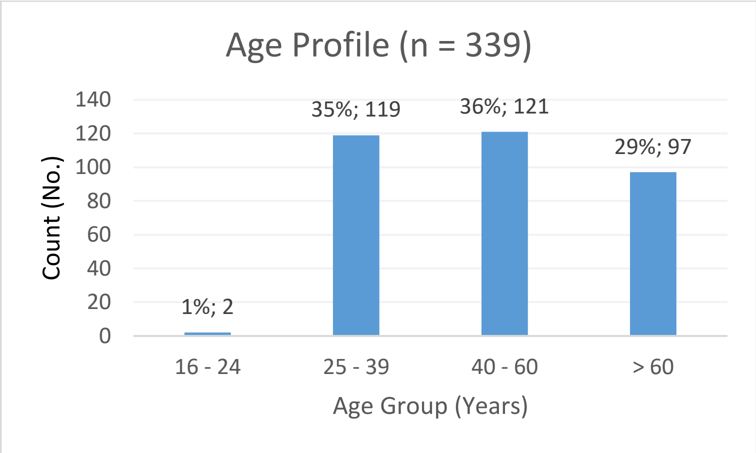


Figure 4.1: Histogram of respondents' age profile

Source: Author.

4.4.1.2 Associated Gender

Figure 4.2 illustrates the percentage and frequency results of a nominal scale question that was used to capture the respondent's associated gender. This is further discussed in section 5.2.3.2.

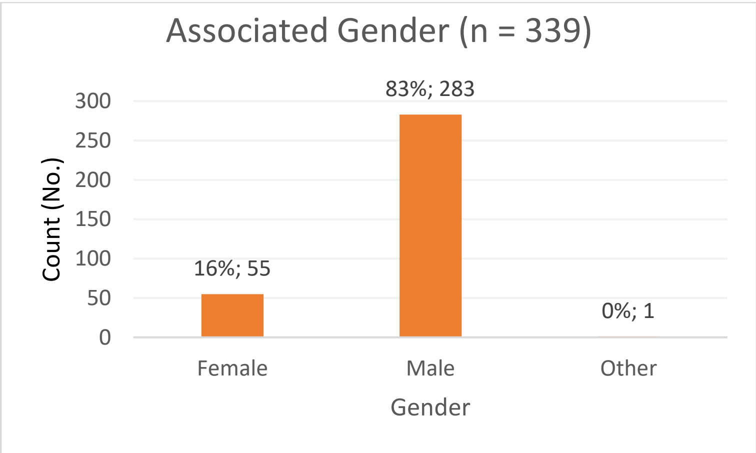


Figure 4.2: Histogram of respondents' gender profile

Source: Author.

4.4.1.3 Associated Race

Figure 4.3 illustrates the percentage and frequency results of a nominal scale question that was used to capture the respondent's associated gender. This is further discussed in section 5.2.3.3.

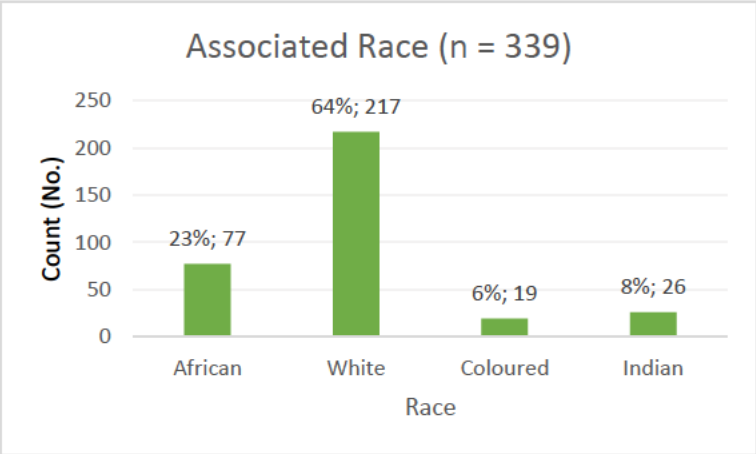


Figure 4.3: Histogram of respondents' race profile

Source: Author.

4.4.2 Demographics – Engineering Experience

4.4.2.1 Engineering Discipline

Figure 4.4 illustrates the percentage and frequency results of a nominal scale question that was used to capture the particular engineering discipline that the respondent belongs to. This is further discussed in section 5.2.3.4.

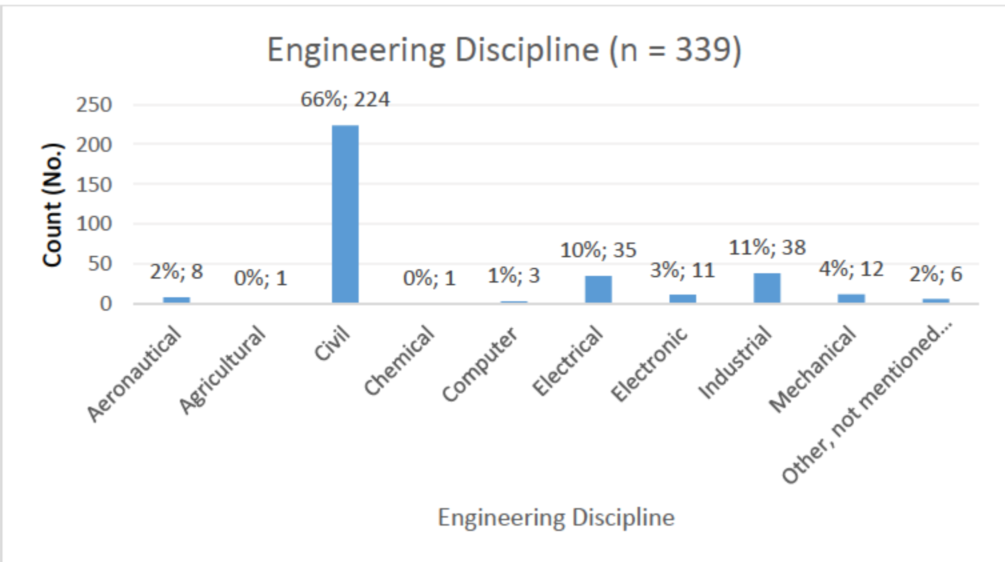


Figure 4.4: Histogram of respondents' engineering disciplines

Source: Author.

4.4.2.2 Status of Professional Registration

Figure 4.5 illustrates the percentage and frequency results of a nominal scale question that was used to capture the status of professional registration of the respondents. This is further discussed in section 5.2.3.5.

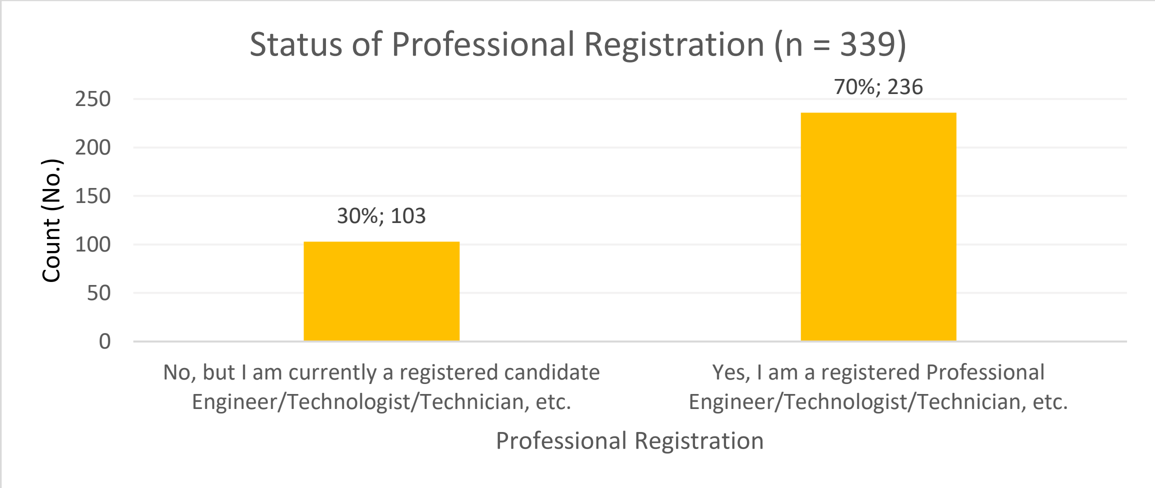


Figure 4.5: Histogram of respondents' professional registration level with ECSA

Source: Author.

4.4.2.3 Employment Sector

Figure 4.6 illustrates the results of a nominal scale question that was used to capture in which sector respondents were employed. This is further discussed in section 5.2.3.6.

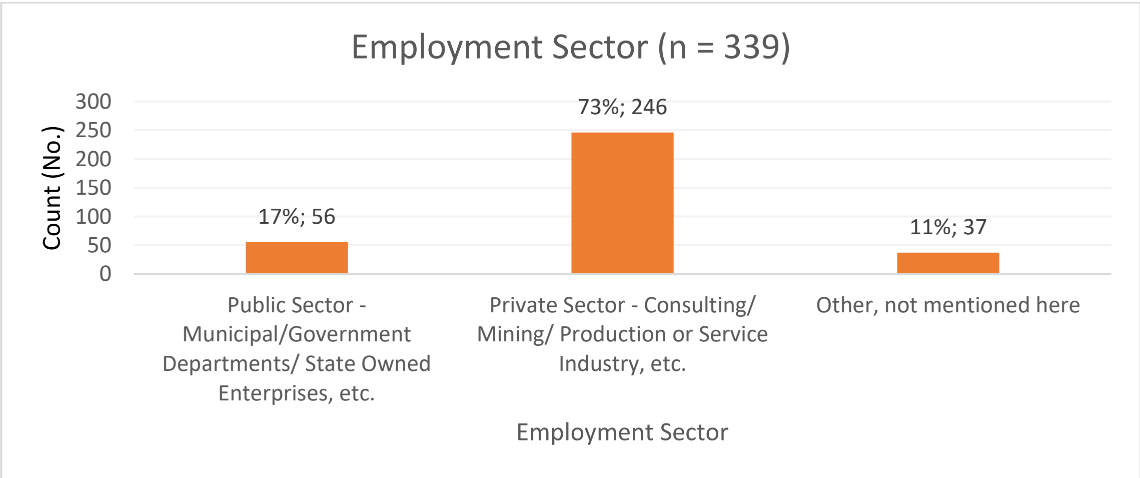


Figure 4.6: Histogram of respondents' employment sectors

Source: Author.

4.4.2.4 Engineering Experience

Figure 4.7 illustrates the percentage and frequency results of a nominal scale question that was used to capture the years of engineering experience of respondents. This is further discussed in section 5.2.3.7.

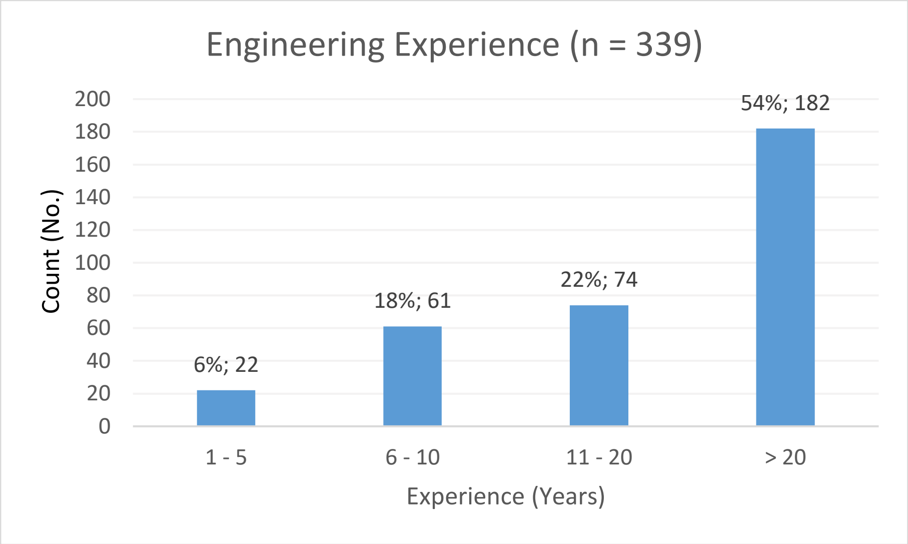


Figure 4.7: Histogram of respondents' engineering experience

Source: Author.

4.4.3 Value of Specific Engineering Leadership Competencies in SA

The following results outline how valued the mentioned Engineering Leadership competencies are perceived to be by members of ECSA within the South African engineering industry.

4.4.3.1 Engineering Leadership Responsibilities

Figure 4.8 illustrates the level of perceived importance of each Engineering Leadership responsibility within the specific work of the local engineering respondents. The items are ranked in order of the derived mean score of importance. This is further discussed in section 5.2.4.1.

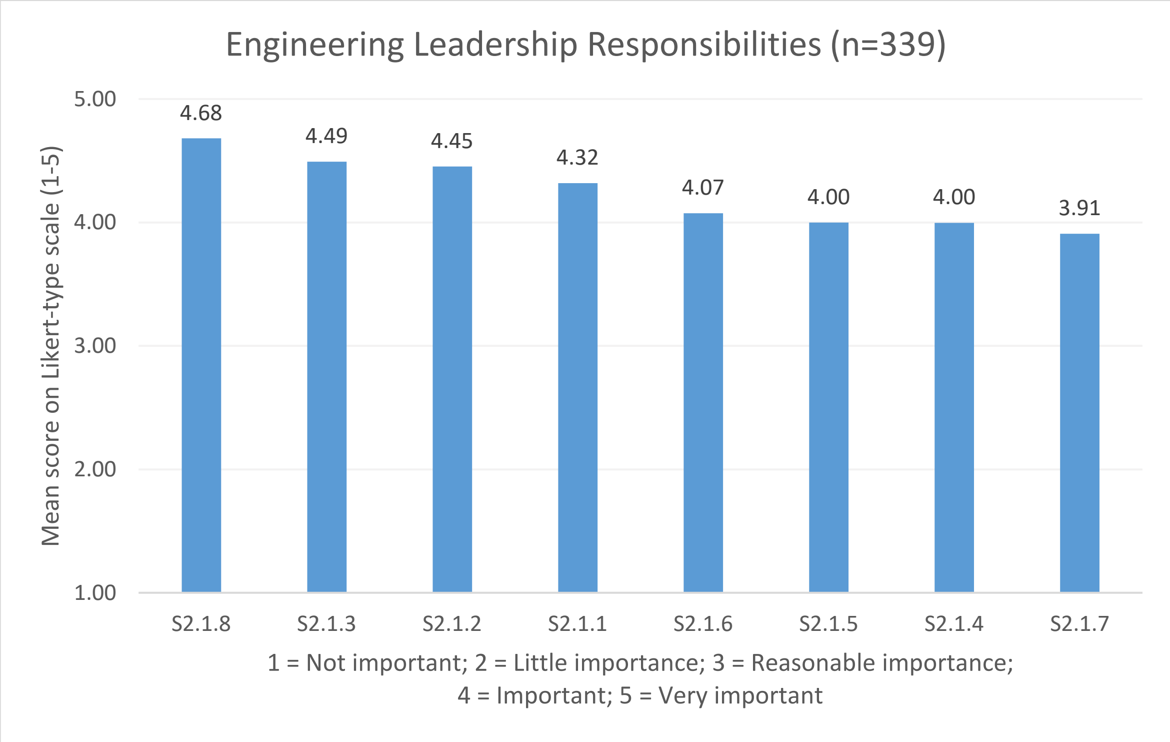


Chart descriptions (in ranked order)

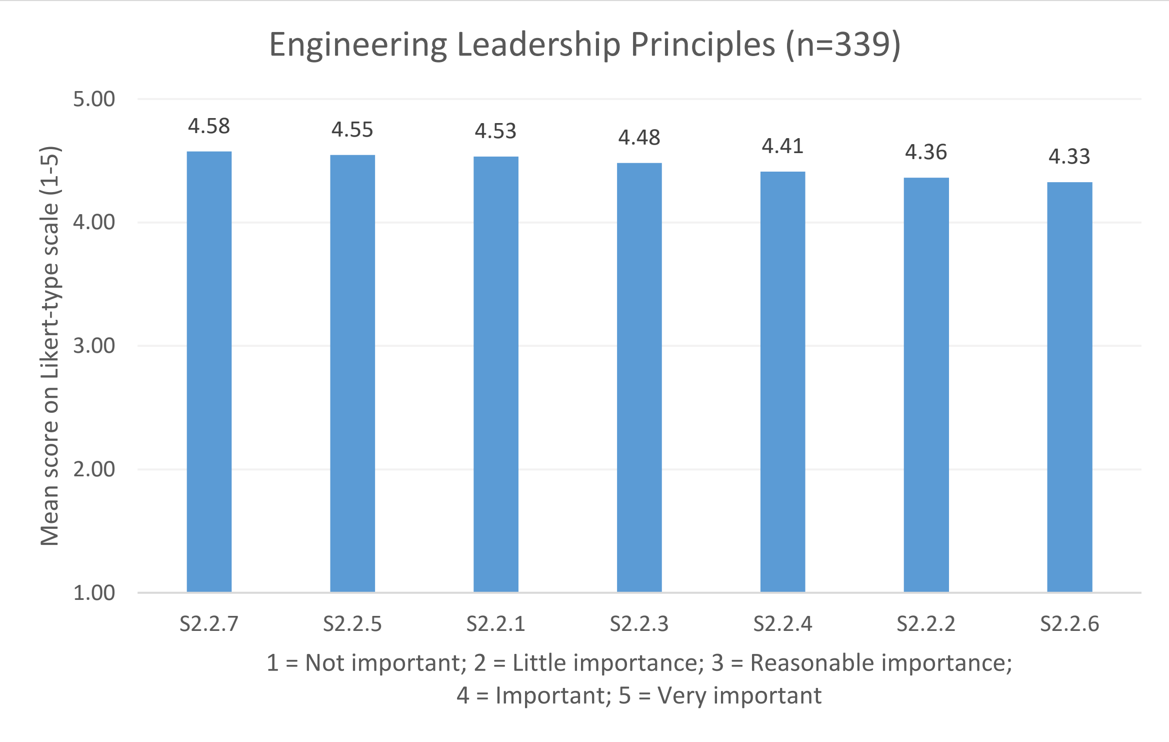
S2.1.8	Upholding and leading good ethical behaviour
S2.1.3	Developing and maintaining trust
S2.1.2	Clearly planning and organising resources
S2.1.1	Being able to develop and engage others in a common vision
S2.1.6	Heightening motivation
S2.1.5	Inspiring creativity
S2.1.4	Sharing perspectives
S2.1.7	Being sensitive to competing needs

Figure 4.8: Mean scoring of the perceived importance of Engineering Leadership responsibilities

Source: Author.

4.4.3.2 Engineering Leadership Principles

Figure 4.9 illustrates the level of perceived importance of each Engineering Leadership principle within the specific work of the local engineering respondents. The items are ranked in order of the derived mean score of importance. This is further discussed in section 5.2.4.2.



<u>Chart descriptions (in ranked order)</u>

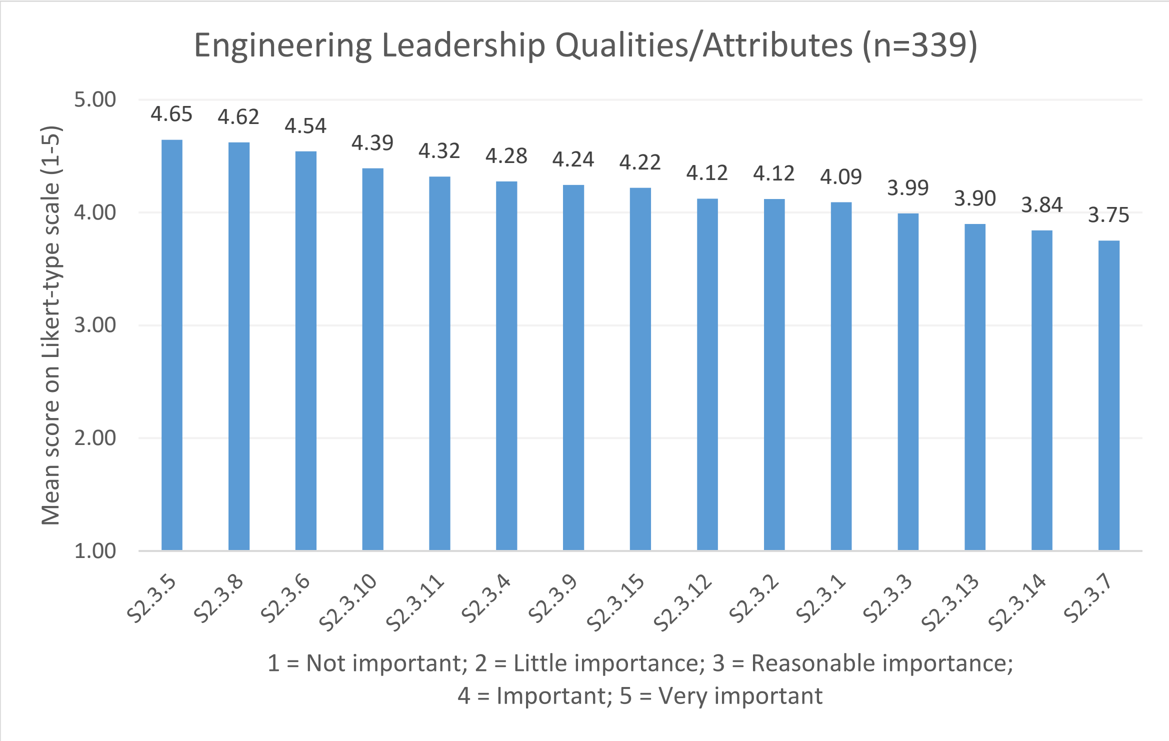
S2.2.7	Ensuring that a project is understood, supervised and accomplished
S2.2.5	Seeking responsibility and taking responsibility for one's actions
S2.2.1	Being technically competent
S2.2.3	Making sound and timely decisions
S2.2.4	Setting the example
S2.2.2	Knowing oneself (abilities) and seeking self-improvement
S2.2.6	Communicating with and developing subordinates both as individuals and as a team

Figure 4.9: Mean scoring of the perceived importance of Engineering Leadership principles

Source: Author.

4.4.3.3 Engineering Leadership Qualities/Attributes

Figure 4.10 illustrates the level of perceived importance of each Engineering Leadership quality/attribute within the specific work of the local engineering respondents. The items are ranked in order of the derived mean score of importance. This is further discussed in section 5.2.4.3.



<u>Chart descriptions (in ranked order)</u>

S2.3.5	Engineering competence
S2.3.8	High ethical standards
S2.3.6	Commitment
S2.3.10	Communication skills
S2.3.11	Discipline
S2.3.4	Initiative
S2.3.9	Adaptability
S2.3.15	Persistence
S2.3.12	Confidence
S2.3.2	Enthusiasm
S2.3.1	Vision
S2.3.3	Industriousness
S2.3.13	Courage
S2.3.14	Curiosity
S2.3.7	Selflessness

Figure 4.10: Mean scoring of the perceived importance of Engineering Leadership qualities/attributes

Source: Author.

4.4.4 Perceived Level of Engineering Leadership Competence in SA

4.4.4.1 Awareness of Formal Engineering Leadership Development

Figure 4.11 illustrates the feedback as to whether respondents were aware that Engineering Leadership can be developed (taught and learned) at undergraduate level. This is further discussed in section 5.2.5.1.

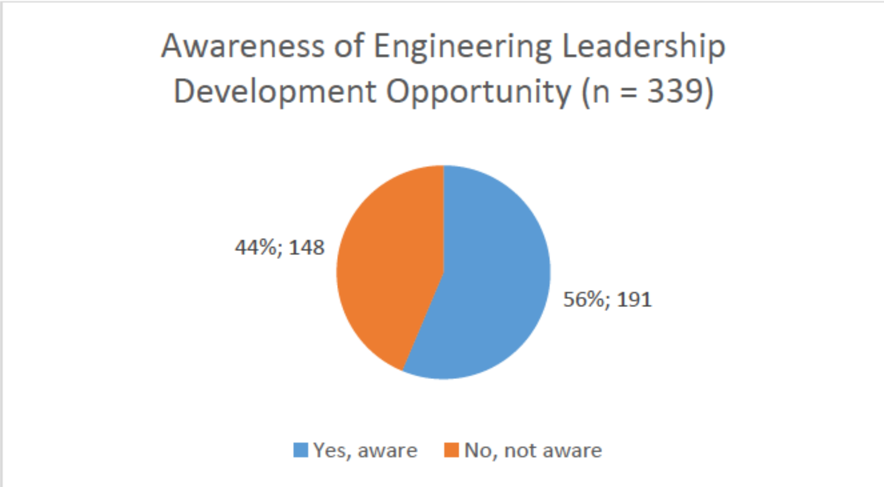


Figure 4.11: Current awareness of Engineering Leadership development opportunity

Source: Author.

4.4.4.2 Perceived Level of Engineering Leadership Knowledge

Figure 4.12 illustrates the perceived level of knowledge of current local engineering graduates with regards to the topic of Engineering Leadership. This is further discussed in section 5.2.5.2.

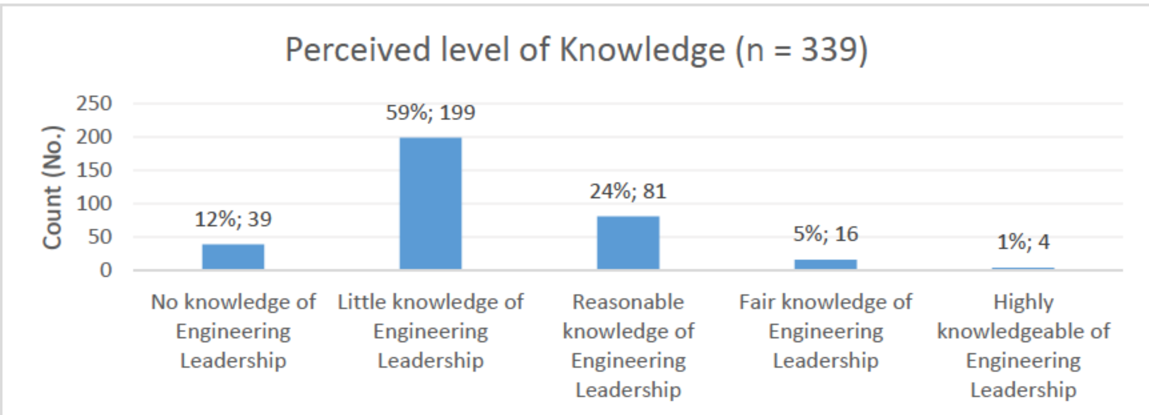


Figure 4.12: Perceived level of Engineering Leadership knowledge possessed by current graduates

Source: Author.

4.4.4.3 Perceived level of Engineering Leadership Competence

Figure 4.13 illustrates the perceived level of competence of current local engineering graduates with regards to the topic of Engineering Leadership. This is further discussed in section 5.2.5.3.

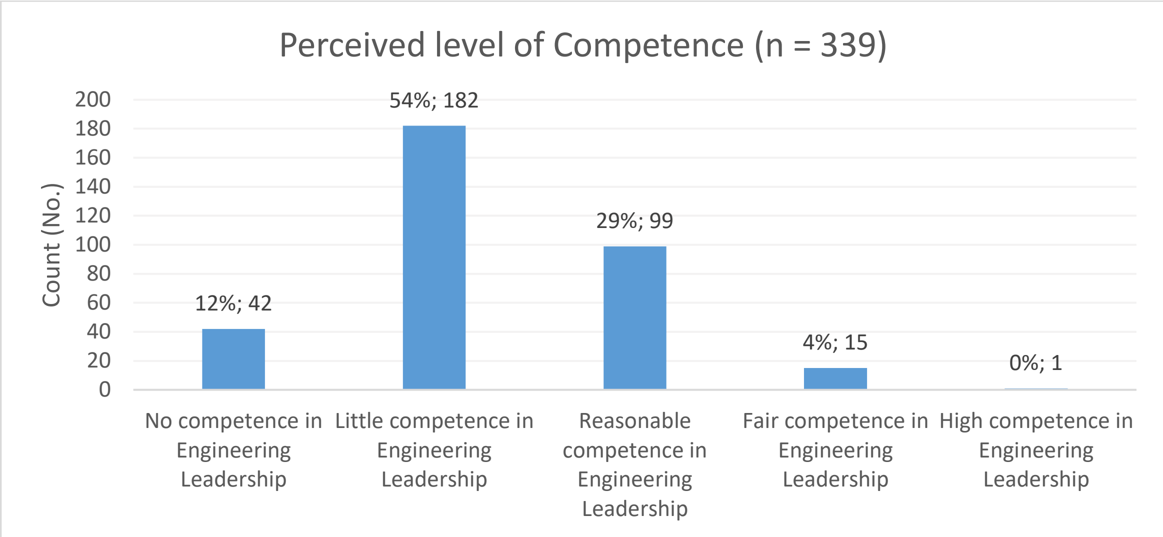


Figure 4.13: Perceived level of Engineering Leadership competence possessed by current graduates

Source: Author.

4.4.4.4 Perceived Engineering Leadership Competency Shortfalls (or gaps)

Figure 4.14 illustrates the level of perceived Engineering Leadership competence shortfalls (or gaps) of current local engineering graduates. The items are ranked in order of the derived mean score of shortfalls (or gaps). This is further discussed in section 5.2.5.4.

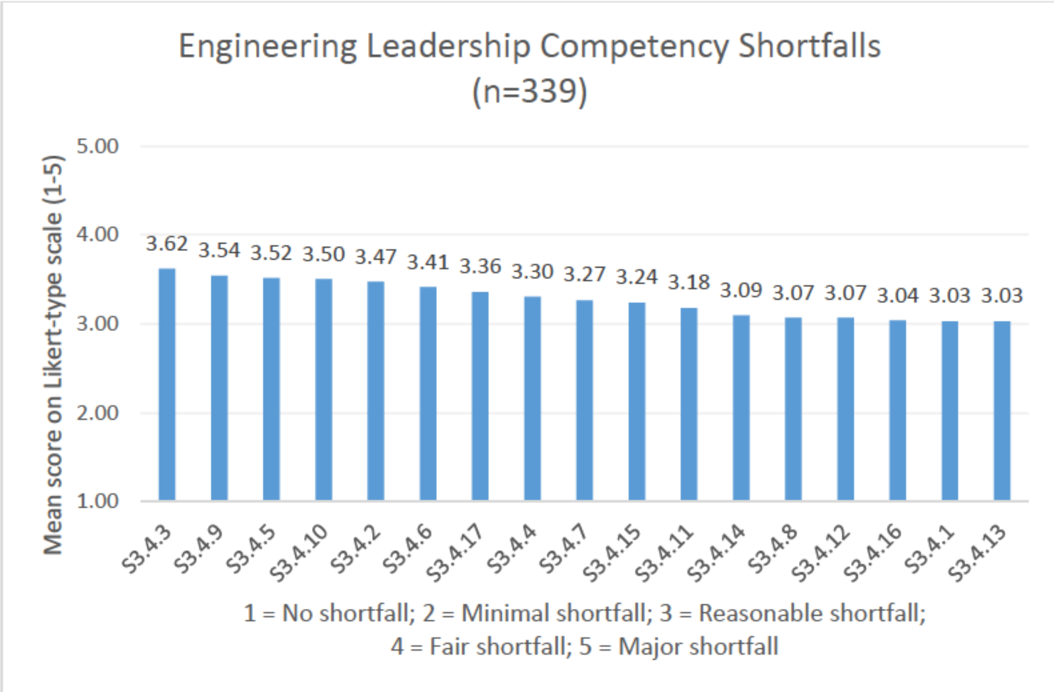


Chart descriptions (in ranked order)

S3.4.3	Client/customer relations skills
S3.4.9	Ability to assess risk
S3.4.5	Industry/organisational knowledge
S3.4.10	Sense of urgency and will to deliver on time
S3.4.2	Written and oral communication skills
S3.4.6	Decision making skills
S3.4.17	Planning skills
S3.4.4	Personal initiative
S3.4.7	Self-management
S3.4.15	Quality orientated
S3.4.11	Resourcefulness and flexibility
S3.4.14	General knowledge
S3.4.8	Problem solving skills
S3.4.12	Trust and loyalty in a team setting
S3.4.16	Creativity and Innovation
S3.4.1	Engineering knowledge
S3.4.13	Ability to relate to others

Figure 4.14: Perceived level of Engineering Leadership competence shortfall by graduates

Source: Author.

4.4.5 Preferred Framework for any future ELE in SA

4.4.5.1 Consensus regarding the Incorporation of any ELE

Figure 4.15 illustrates the consensus of the local industry as to whether ELE should be incorporated into South African tertiary education institutions. This is further discussed in section 5.2.6.1.

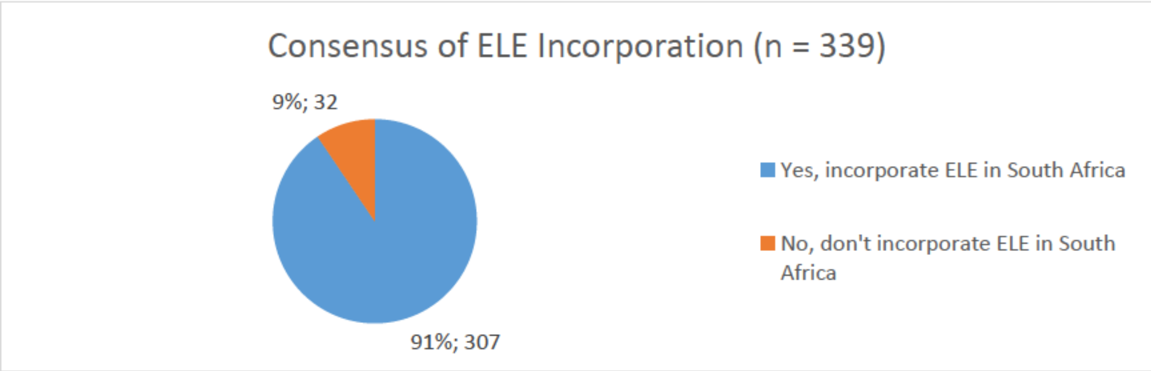


Figure 4.15: Consensus regarding the desire for any ELE incorporation in SA

Source: Author.

4.4.5.2 Consensus regarding the Level/Extent of any ELE Implementation

Figure 4.16 illustrates the preferred level/extent of any ELE implementation within South African tertiary education institutions, by the local industry. This is further discussed in section 5.2.6.2.

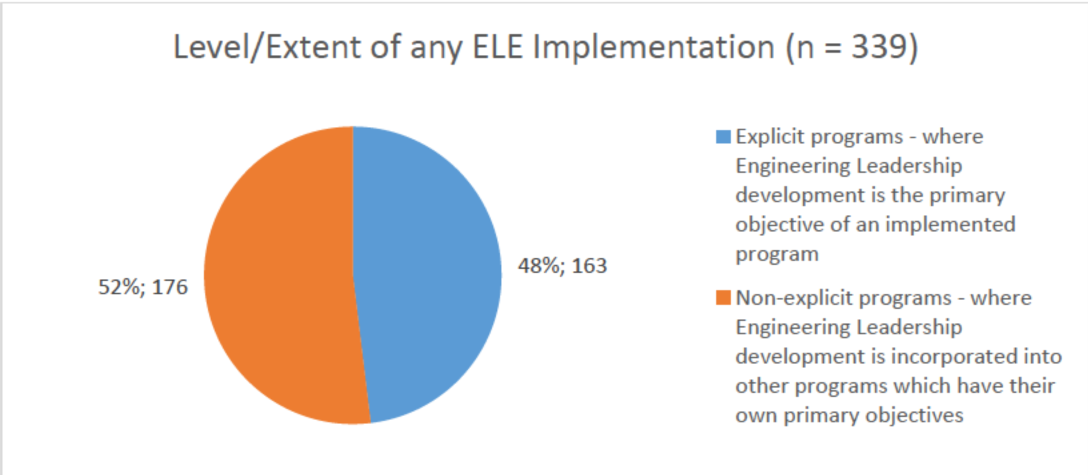
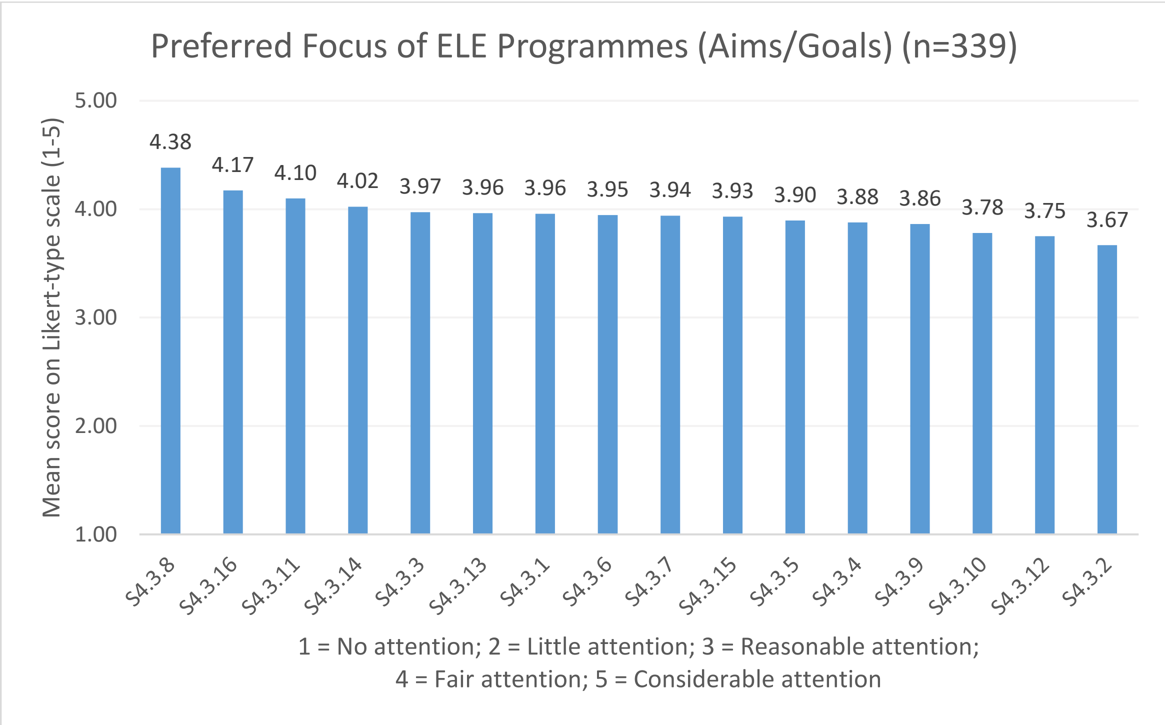


Figure 4.16: Consensus regarding the level/extent of any ELE implementation in SA

Source: Author.

4.4.5.3 Preferred Level of Focus to Specific Aims/Goals of ELE Programmes

Figure 4.17 illustrates the level of preference of local engineering respondents for the presented aims/goals which any newly developed ELE programmes may take in SA. The items are ranked in order of the derived mean score of importance. This is further discussed in section 5.2.6.3.



<u>Chart descriptions (in ranked order)</u>

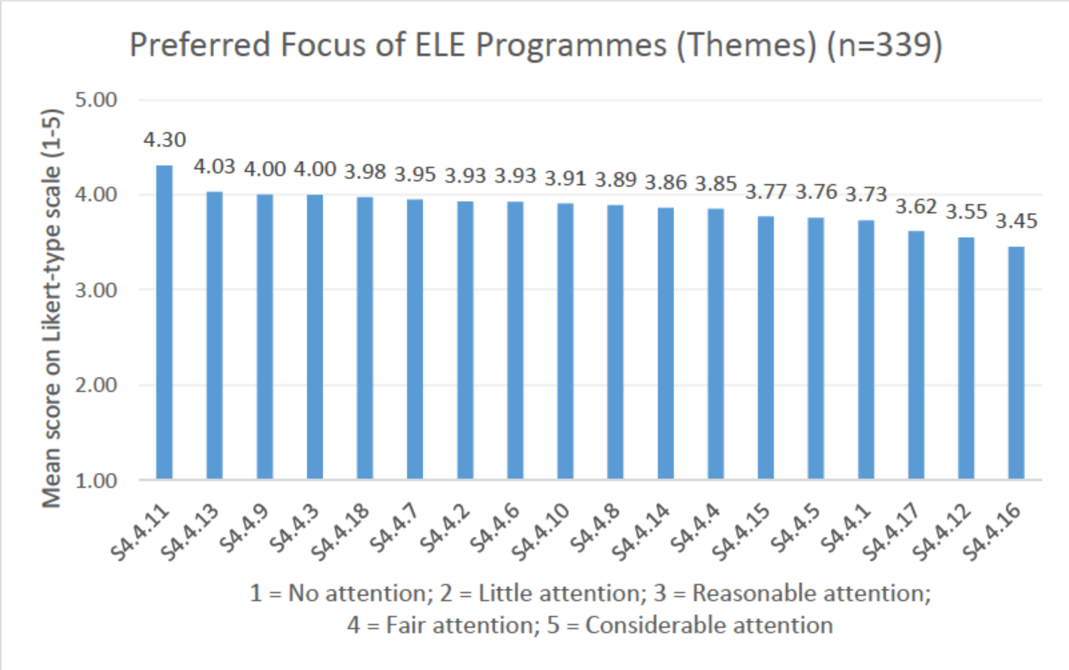
S4.3.8	Improve ethical leadership
S4.3.16	Develop desire for demonstrating excellence
S4.3.11	Improve project management skills
S4.3.14	Develop ability to engage others
S4.3.3	Improved understanding of business concepts
S4.3.13	Develop ability to obtain team effectiveness
S4.3.1	Development of leadership skills
S4.3.6	Improved ability to solve business challenges
S4.3.7	Improved interpersonal skills
S4.3.15	Develop personal awareness and growth
S4.3.5	Improved skills in current technology
S4.3.4	Development of entrepreneurial skills
S4.3.9	Improve visionary leadership
S4.3.10	Improve industry leadership
S4.3.12	Develop desire for a positive impact on world challenges
S4.3.2	Development of managerial (administrative) skills

Figure 4.17: Preferred focus of ELE programmes (aims/goals)

Source: Author.

4.4.5.4 Preferred Level of Focus to Specific Themes of ELE Programmes

Figure 4.18 illustrates the level of preference of local engineering respondents for the presented themes which any newly developed ELE programmes may take in SA. The items are ranked in order of the derived mean score of importance. This is further discussed in section 5.2.6.4.



<u>Chart descriptions (in ranked order)</u>

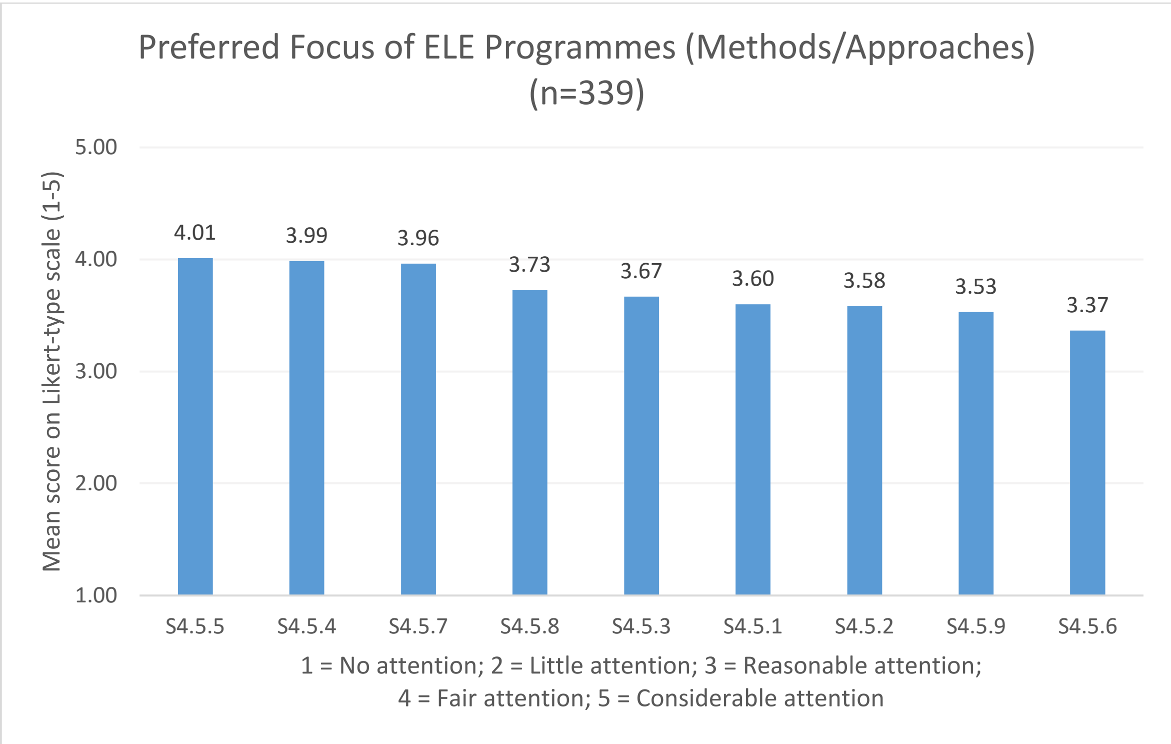
S4.4.11	Training in ethics in engineering
S4.4.13	Training in communication skills
S4.4.9	Development of conflict management knowledge and skills
S4.4.3	Development of project management knowledge and skills
S4.4.18	Training in working effectively with others
S4.4.7	Development of teamwork knowledge and skills
S4.4.2	Understanding of business fundamentals
S4.4.6	Development of presentation knowledge and skills
S4.4.10	Training in how to effectively lead and motivate
S4.4.8	Development of self-awareness and emotional intelligence knowledge and skills
S4.4.14	Training in managing interdisciplinary engineering teams
S4.4.4	Development of negotiation knowledge and skills
S4.4.15	Development of innovation knowledge and skills
S4.4.5	Development of career management knowledge and skills
S4.4.1	Understanding of leadership theory and practice
S4.4.17	Training in finance, marketing and investment
S4.4.12	Development of public relations knowledge and skills
S4.4.16	Development of public policy knowledge and skills

Figure 4.18: Preferred focus of ELE programmes (themes)

Source: Author.

4.4.5.5 Preferred Level of Focus on Specific Methods/Approaches to ELE Programmes

Figure 4.19 illustrates the level of preference of local engineering respondents for the presented methods/approaches which any newly developed ELE programmes may take in SA. The items are ranked in order of the derived mean score of importance. This is further discussed in section 5.2.6.5.



<u>Chart descriptions (in ranked order)</u>

S4.5.5	Peer/ faculty/ industry mentoring programmes
S4.5.4	Industry vacation work experience
S4.5.7	Personal leadership development plan(s) with mentor
S4.5.8	Coordinated networking opportunities with leaders
S4.5.3	Team learning/scale projects
S4.5.1	Leadership coursework/modules
S4.5.2	Leadership workshops/seminars
S4.5.9	On campus/community leadership opportunities
S4.5.6	Leadership reflection journals / personal portfolios

Figure 4.19: Preferred focus of ELE programmes (methods/approaches)

Source: Author.

4.5 Inferential Statistics of Study

The following section summarises further statistical analysis that was carried out on the survey data to: 1) identify correlated items and any associated unobserved factors within specific questions; 2) identify any significant difference in the way respondents scored each item within the questions; 3) identify any significant associations between the demographic variables and the associated scoring of specific items; and, 4) identify significant correlations between items within a question. The results are discussed further in chapters 5 and 6.

4.5.1 Factor Analysis of Data

A summary of the Kaiser-Meyer-Olkin Measure of Sample Adequacy (KMO) and the Bartlett's Test of Sphericity values derived from the data are provided in Table 4.2 below. The KMO shows the proportion of variance in measured items, possibly caused by unobserved factors. High values greater than 0.5 and close to 1.0 indicate that factor analysis should be considered for the data set. Additionally, Bartlett's tests whether items are unrelated, if disproved correlations may be present. Low values of the significant level (<0.05) indicate that items may be related and factor analysis should be carried out.

Table 4.2: KMO and Bartlett's test for the suitability of factor analysis

Section	Sub-section tested	KMO Measure of Sampling Adequacy	Bartlett's Test of Sphericity		
			Approx. Chi-Square	df	Sig.
S2.1	Engineering Leadership Responsibilities	0.858	1073.140	28	0.000
S2.2	Engineering Leadership Principles	0.841	985.280	21	0.000
S2.3	Engineering Leadership Qualities and Attributes	0.913	2402.780	105	0.000
S3.4	Engineering Leadership Shortfalls	0.907	2759.053	136	0.000
S4.3	Aims and Goals of ELE Programmes	0.909	2956.995	120	0.000
S4.4	Themes of ELE Programmes	0.953	3723.106	153	0.000
S4.5	Approaches to Engineering Leadership Education	0.895	1450.082	36	0.000

Source: Author.

The results of the mentioned tests indicated in Table 4.2 show that the data satisfied the conditions for further factor analysis.

The individual questions were thus further analysed using factor analysis which reduced the numerous variables of each tested area into fewer potential sub-components/themes.

Table 4.3 illustrates the component matrix derived from the factor analysis when testing how important the specific Engineering Leadership responsibilities are to the respondent's engineering work. The respective component is further discussed in section 5.2.4.1.

Table 4.3: Factor analysis for Engineering Leadership responsibilities scoring

Item Description	**Component 1**
Being able to develop and engage others in a common vision	0.668
Clearly planning and organising resources	0.650
Developing and maintaining trust	0.680
Sharing perspectives	0.791
Inspiring creativity	0.778
Heightening motivation	0.783
Being sensitive to competing needs	0.732
Upholding and leading good ethical behaviour	0.637

Source: Author.

Table 4.4 illustrates the component matrix derived from the factor analysis when testing how important the specific Engineering Leadership principles are to the respondent's engineering work. The respective component is further discussed in section 5.2.4.2.

Table 4.4: Factor analysis for Engineering Leadership principles scoring

Item Description	**Component 1**
Being technically competent	0.554
Knowing oneself (abilities) and seeking self-improvement	0.709
Making sound and timely decisions	0.796
Setting the example	0.799
Seeking responsibility and taking responsibility for one's actions	0.776
Communicating with and developing subordinates both as individuals and as a team	0.755
Ensuring that a project is understood, supervised and accomplished	0.772

Source: Author.

Table 4.5 illustrates the component matrix derived from the factor analysis when testing how important the specific Engineering Leadership qualities/attributes are to the respondent's engineering work. The respective components are further discussed in section 5.2.4.3.

Table 4.5: Factor analysis for Engineering Leadership qualities/attributes scoring

Item Description	Component 1	Component 2
Vision	0.409	0.582
Enthusiasm	0.580	0.395
Industriousness	0.581	0.253
Initiative	0.487	0.598
Competence	0.021	0.791
Commitment	0.380	0.659
Selflessness	0.546	0.435
High ethical standards	0.157	0.719
Adaptability	0.532	0.341
Communication skills	0.428	0.438
Discipline	0.553	0.517
Confidence	0.791	0.107
Courage	0.853	0.118
Curiosity	0.726	0.214
Persistence	0.699	0.311

Source: Author.

Table 4.6 illustrates the component matrix derived from the factor analysis when testing the level of shortfall in specific Engineering Leadership competencies. The respective components are further discussed in section 5.2.5.4.

Table 4.6: Factor analysis for Engineering Leadership shortfalls

Item Description	Component 1	Component 2	Component 3
Engineering knowledge	0.025	0.130	0.846
Written and oral communication skills	0.117	0.338	0.685
Client/customer relations skills	0.051	0.782	0.086
Personal initiative	0.360	0.427	0.293
Industry/organisational knowledge	0.087	0.749	0.098
Decision making skills	0.319	0.694	0.228
Self-management	0.509	0.512	0.164
Problem solving skills	0.464	0.237	0.587
Ability to assess risk	0.348	0.571	0.252
Sense of urgency and will to deliver on time	0.559	0.506	0.169
Resourcefulness and flexibility	0.712	0.316	0.201
Trust and loyalty in a team setting	0.780	0.195	0.097
Ability to relate to others	0.768	0.122	0.075
General knowledge	0.460	0.018	0.581
Quality orientated	0.561	0.203	0.521
Creativity and Innovation	0.610	0.083	0.423
Planning skills	0.494	0.307	0.389

Source: Author.

Table 4.7 illustrates the component matrix derived from the factor analysis when testing the level of desired for specific aims/goals to ELE programmes. The respective components are further discussed in section 5.2.6.3.

Table 4.7: Factor analysis for aims/goals to ELE programmes

Item Description	**Compo-nent 1**	**Compo-nent 2**	**Compo-nent 3**
Development of leadership skills	0.458	0.576	0.119
Development of managerial (administrative) skills	0.139	0.770	0.191
Improved understanding of business concepts	0.135	0.768	0.186
Development of entrepreneurial skills	0.305	0.630	0.102
Improved skills in current technology	0.028	0.345	0.753
Improved ability to solve business challenges	0.425	0.670	0.164
Improved interpersonal skills	0.637	0.264	0.344
Improve ethical leadership	0.508	0.165	0.436
Improve visionary leadership	0.757	0.371	0.050
Improve industry leadership	0.631	0.532	0.088
Improve project management skills	0.174	0.471	0.398
Develop desire for a positive impact on world challenges	0.479	0.311	0.488
Develop ability to obtain team effectiveness	0.717	0.301	0.271
Develop ability to engage others	0.810	0.209	0.195
Develop personal awareness and growth	0.623	0.084	0.496
Develop desire for demonstrating excellence	0.387	0.044	0.752

Source: Author.

Table 4.8 illustrates the component matrix derived from the factor analysis when testing the level of desired for specific themes to ELE programmes. The respective components are further discussed in section 5.2.6.4.

Table 4.8: Factor analysis for themes to ELE programmes

Item Description	**Component 1**
Understanding of leadership theory and practice	0.687
Understanding of business fundamentals	0.694
Development of project management knowledge and skills	0.575
Development of negotiation knowledge and skills	0.742
Development of career management knowledge and skills	0.726
Development of presentation knowledge and skills	0.728
Development of teamwork knowledge and skills	0.790
Development of self-awareness and emotional intelligence knowledge and skills	0.763
Development of conflict management knowledge and skills	0.767
Training in how to effectively lead and motivate	0.769
Training in ethics in engineering	0.597
Development of public relations knowledge and skills	0.806
Training in communication skills	0.720
Training in managing interdisciplinary engineering teams	0.733
Development of innovation knowledge and skills	0.706
Development of public policy knowledge and skills	0.754
Training in finance, marketing and investment	0.720
Training in working effectively with others	0.775

Source: Author.

Table 4.9 illustrates the component matrix derived from the factor analysis when testing the level of desired for specific methods/approaches to ELE programmes. The respective components are further discussed in section 5.2.6.5.

Table 4.9: Factor analysis for methods/approaches to ELE programmes

Item Description	Component 1	Component 2
Leadership coursework/modules	0.823	0.082
Leadership workshops/seminars	0.793	0.092
Team learning/scale projects	0.690	0.309
Industry vacation work experience	0.099	0.878
Peer/ faculty/ industry mentoring programmes	0.327	0.814
Leadership reflection journals / personal portfolios	0.723	0.250
Personal leadership development plan(s) with mentor	0.660	0.442
Coordinated Networking opportunities with leaders	0.628	0.479
On campus/Community leadership opportunities	0.719	0.344

Source: Author.

4.5.2 Section Analysis of Data

The following section provides results of the analysis carried out on the scoring pattern of individual items. The binomial test was carried out with the null hypothesis claim that there is no difference between the number that scored above the central score (>3) as there were who scored below. A low p-value ($p<0.05$) indicates a significant difference from the null hypothesis, in that more respondents scored higher levels of importance, shortfall or attention.

Table 4.10 illustrates the level of agreement of respondents when testing how important the specific Engineering Leadership responsibilities are to their engineering work. The test results are further discussed in section 5.2.4.1.

Table 4.10: Section analysis for Engineering Leadership responsibilities scoring

Item Description	**Mean**	**Std. Deviation**	**Binomial Test (p-value)**
Being able to develop and engage others in a common vision	4.32	0.76	0.000
Clearly planning and organising resources	4.45	0.75	0.000
Developing and maintaining trust	4.49	0.72	0.000
Sharing perspectives	4.00	0.81	0.000
Inspiring creativity	4.00	0.96	0.000
Heightening motivation	4.07	0.90	0.000
Being sensitive to competing needs	3.91	0.90	0.000
Upholding and leading good ethical behaviour	4.68	0.64	0.000

Source: Author.

Table 4.11 illustrates the level of agreement of respondents when testing how important the specific Engineering Leadership principles are to their engineering work. The test results are further discussed in section 5.2.4.2.

Table 4.11: Section analysis for Engineering Leadership principles scoring

Item Description	**Mean**	**Std. Deviation**	**Binomial Test (p-value)**
Being technically competent	4.53	0.74	0.000
Knowing oneself (abilities) and seeking self-improvement	4.36	0.75	0.000
Making sound and timely decisions	4.48	0.69	0.000
Setting the example	4.41	0.75	0.000
Seeking responsibility and taking responsibility for one's actions	4.55	0.75	0.000
Communicating with and developing subordinates both as individuals and as a team	4.33	0.84	0.000
Ensuring that a project is understood, supervised and accomplished	4.58	0.72	0.000

Source: Author.

Table 4.12 illustrates the level of agreement of respondents when testing how important the specific Engineering Leadership qualities/attributes are to their engineering work. The test results are further discussed in section 5.2.4.3.

Table 4.12: Section analysis for Engineering Leadership qualities/attributes scoring

Item Description	Mean	Std. Deviation	Binomial Test (p-value)
Vision	4.09	0.87	0.000
Enthusiasm	4.12	0.81	0.000
Industriousness	3.99	0.77	0.000
Initiative	4.28	0.81	0.000
Competence	4.65	0.63	0.000
Commitment	4.54	0.68	0.000
Selflessness	3.75	0.92	0.000
High ethical standards	4.62	0.67	0.000
Adaptability	4.24	0.69	0.000
Communication skills	4.39	0.73	0.000
Discipline	4.32	0.77	0.000
Confidence	4.12	0.79	0.000
Courage	3.90	0.93	0.000
Curiosity	3.84	0.93	0.000
Persistence	4.22	0.83	0.000

Source: Author.

Table 4.13 illustrates the level of agreement of respondents when testing how much leadership competency shortfalls need to be addressed in respective areas, in undergraduate engineers. The test results are further discussed in section 5.2.5.4.

Table 4.13: Section analysis for scoring of leadership competency shortfalls

Item Description	**Mean**	**Std. Deviation**	**Binomial Test (p-value)**
Engineering knowledge	3.03	1.08	0.000
Written and oral communication skills	3.47	1.08	0.664
Client/customer relations skills	3.62	0.94	0.128
Personal initiative	3.30	0.97	0.003
Industry/organisational knowledge	3.52	0.97	1.000
Decision making skills	3.41	0.94	0.050
Self-management	3.27	0.99	0.000
Problem solving skills	3.07	1.02	0.000
Ability to assess risk	3.54	1.00	0.232
Sense of urgency and will to deliver on time	3.50	1.14	0.277
Resourcefulness and flexibility	3.18	0.98	0.000
Trust and loyalty in a team setting	3.07	0.96	0.000
Ability to relate to others	3.03	0.99	0.000
General knowledge	3.09	0.97	0.000
Quality orientated	3.24	1.02	0.000
Creativity and Innovation	3.04	1.04	0.000
Planning skills	3.36	0.98	0.017

Source: Author.

Table 4.14 illustrates the level of agreement of respondents when testing how much attention should be given to the specific aims/goals of any future ELE programmes, locally. The test results are further discussed in section 5.2.6.3.

Table 4.14: Section analysis for ELE programme scoring (aims/goals)

Item Description	**Mean**	**Std. Deviation**	**Binomial Test (p-value)**
Development of leadership skills	3.96	0.91	0.000
Development of managerial (administrative) skills	3.67	0.93	0.005
Improved understanding of business concepts	3.97	0.81	0.000
Development of entrepreneurial skills	3.88	0.96	0.000
Improved skills in current technology	3.90	0.97	0.000
Improved ability to solve business challenges	3.95	0.85	0.000
Improved interpersonal skills	3.94	0.90	0.000
Improve ethical leadership	4.38	0.86	0.000
Improve visionary leadership	3.86	0.96	0.000
Improve industry leadership	3.78	0.91	0.000
Improve project management skills	4.10	0.86	0.000
Develop desire for a positive impact on world challenges	3.75	1.04	0.000
Develop ability to obtain team effectiveness	3.96	0.90	0.000
Develop ability to engage others	4.02	0.84	0.000
Develop personal awareness and growth	3.93	0.91	0.000
Develop desire for demonstrating excellence	4.17	0.85	0.000

Source: Author.

Table 4.15 illustrates the level of agreement of respondents when testing how much attention should be given to the specific themes of any future ELE programmes, locally. The test results are further discussed in section 5.2.6.4.

Table 4.15: Section analysis for ELE programme scoring (themes)

Item Description	Mean	Std. Deviation	Binomial Test (p-value)
Understanding of leadership theory and practice	3.73	0.94	0.000
Understanding of business fundamentals	3.93	0.88	0.000
Development of project management knowledge and skills	4.00	0.90	0.000
Development of negotiation knowledge and skills	3.85	0.89	0.000
Development of career management knowledge and skills	3.76	0.91	0.000
Development of presentation knowledge and skills	3.93	0.92	0.000
Development of teamwork knowledge and skills	3.95	0.88	0.000
Development of self-awareness and emotional intelligence knowledge and skills	3.89	0.98	0.000
Development of conflict management knowledge and skills	4.00	0.92	0.000
Training in how to effectively lead and motivate	3.91	0.94	0.000
Training in ethics in engineering	4.30	0.90	0.000
Development of public relations knowledge and skills	3.55	0.98	0.515
Training in communication skills	4.03	0.97	0.000
Training in managing interdisciplinary engineering teams	3.86	0.99	0.000

Item Description	Mean	Std. Deviation	Binomial Test (p-value)
Development of innovation knowledge and skills	3.77	0.98	0.000
Development of public policy knowledge and skills	3.45	1.01	0.828
Training in finance, marketing and investment	3.62	1.05	0.012
Training in working effectively with others	3.98	0.91	0.000

Source: Author.

Table 4.16 illustrates the level of agreement of respondents when testing how much attention should be given to the specific approaches/methods of any future ELE programmes, locally. The test results are further discussed in section 5.2.6.5.

Table 4.16: Section analysis for ELE programme scoring (approaches/methods)

Item Description	Mean	Std. Deviation	Binomial Test (p-value)
Leadership coursework/modules	3.60	1.01	0.103
Leadership workshops/seminars	3.58	1.05	0.022
Team learning/scale projects	3.67	0.94	0.002
Industry vacation work experience	3.99	1.00	0.000
Peer/ faculty/ industry mentoring programmes	4.01	0.91	0.000
Leadership reflection journals / personal portfolios	3.37	1.02	0.082
Personal leadership development plan(s) with mentor	3.96	0.98	0.000
Coordinated Networking opportunities with leaders	3.73	0.99	0.000
On campus/Community leadership opportunities	3.53	1.06	0.447

Source: Author.

4.5.3 Cross-tabulation of Results

The following section provides results of the analysis carried out on the relationship of demographic variables with individual items. The Pearson's chi-square test was carried out with the null hypothesis claim that there is no association between the variable and the specific item being tested. A low p-value ($p<0.05$) indicates a significant difference from the null hypothesis, in that there is a significant relationship identified. All significant relationships are indicated with an asterisk (*).

Table 4.17 illustrates the level of association of respondent's demographics with how important the specific Engineering Leadership responsibilities are to their engineering work.

Table 4.17: Cross-tabulation of demographics with Engineering Leadership responsibilities

Item Description		What is your present age group?	What is your associated gender?	What is your associated race?	Professionally registered member of ECSA?	Which engineering discipline do you work within?	Are you employed within the public or private sector?	Experience within the engineering profession?
Being able to develop and engage others in a common vision	Chi-square	6.790	7.102	12.798	0.390	18.032	5.717	15.554
	df	12	8	12	4	36	8	12
	Sig.	0.871	0.526	0.384	0.983	0.995	0.679	0.213
Clearly planning and organising resources	Chi-square	13.489	19.640	12.014	4.435	25.207	11.276	15.779
	df	12	8	12	4	36	8	12
	Sig.	0.335	.012*	0.445	0.35	0.911	0.187	0.202
Developing and maintaining trust	Chi-square	7.778	6.124	12.945	2.885	22.342	13.022	19.567
	df	12	8	12	4	36	8	12
	Sig.	0.802	0.633	0.373	0.577	0.964	0.111	0.076
Sharing perspectives	Chi-square	10.994	10.482	28.946	3.303	22.454	3.158	19.188
	df	12	8	12	4	36	8	12
	Sig.	0.529	0.233	.004*	0.509	0.962	0.924	0.084
Inspiring creativity	Chi-square	11.185	22.111	20.590	6.353	23.362	12.672	10.699
	df	12	8	12	4	36	8	12
	Sig.	0.513	.005*	0.057	0.174	0.948	0.124	0.555
Heightening motivation	Chi-square	13.885	20.197	21.207	2.632	13.435	8.079	12.095
	df	12	8	12	4	36	8	12
	Sig.	0.308	.010*	.047*	0.621	1	0.426	0.438
Being sensitive to competing needs	Chi-square	15.318	14.622	15.713	1.904	28.354	8.221	12.034
	df	12	8	12	4	36	8	12
	Sig.	0.224	0.067	0.205	0.753	0.814	0.412	0.443
Upholding and leading good ethical behaviour	Chi-square	11.278	14.928	23.425	12.914	17.268	6.604	16.633
	df	12	8	12	4	36	8	12
	Sig.	0.505	0.061	.024*	.012*	0.996	0.58	0.164
* sig. values (p-values) less than 0.05								

Source: Author.

Table 4.18 illustrates the level of association of respondent's demographics with how important the specific Engineering Leadership principles are to their engineering work.

Table 4.18: Cross-tabulation of demographics with Engineering Leadership principles

Item Description		**What is your present age group?**	**What is your associated gender?**	**What is your associated race?**	**Professionally registered member of ECSA?**	**Which engineering discipline do you work within?**	**Are you employed within the public or private sector?**	**Experience within the engineering profession?**
Being technically competent	Chi-square	16.307	5.723	5.046	11.105	40.038	9.299	27.476
	df	12	8	12	4	36	8	12
	Sig.	0.178	0.678	0.956	.025*	0.296	0.318	.007*
Knowing oneself (abilities) and seeking self-improvement	Chi-square	12.311	18.082	10.908	6.648	18.713	11.940	17.325
	df	12	8	12	4	36	8	12
	Sig.	0.421	.021*	0.537	0.156	0.992	0.154	0.138
Making sound and timely decisions	Chi-square	5.327	12.346	22.020	4.988	18.594	10.619	10.607
	df	12	8	12	4	36	8	12
	Sig.	0.946	0.136	.037*	0.289	0.993	0.224	0.563
Setting the example	Chi-square	18.404	7.213	28.256	11.053	16.955	15.306	36.033
	df	12	8	12	4	36	8	12
	Sig.	0.104	0.514	.005*	.026*	0.997	0.053	.000*
Seeking responsibility and taking responsibility for one's actions	Chi-square	14.971	10.173	21.161	11.624	15.105	10.080	17.731
	df	12	8	12	4	36	8	12
	Sig.	0.243	0.253	.048*	.020*	0.999	0.259	0.124
Communicating with and developing subordinates both as individuals and as a team	Chi-square	19.123	14.685	15.158	5.066	18.628	6.601	16.950
	df	12	8	12	4	36	8	12
	Sig.	0.086	0.066	0.233	0.281	0.993	0.58	0.151
Ensuring that a project is understood, supervised and accomplished	Chi-square	14.163	15.785	14.876	8.562	27.052	5.765	24.836
	df	12	8	12	4	36	8	12
	Sig.	0.29	.046*	0.248	0.073	0.859	0.674	.016*

* sig. values (p-values) less than 0.05

Source: Author.

Table 4.19 illustrates the level of association of respondent's demographics with how important the specific Engineering Leadership qualities/attributes are to their engineering work.

Table 4.19: Cross-tabulation of demographics with Engineering Leadership qualities/attributes

Item Description		**What is your present age group?**	**What is your associated gender?**	**What is your associated race?**	**Professionally registered member of ECSA?**	**Which engineering discipline do you work within?**	**Are you employed within the public or private sector?**	**Experience within the engineering profession?**
Vision	Chi-square	9.934	10.259	14.487	10.222	22.553	9.310	16.701
	df	12	8	12	4	36	8	12
	Sig.	0.622	0.247	0.271	.037*	0.961	0.317	0.161
Enthusiasm	Chi-square	17.020	79.037	14.725	19.647	38.507	9.118	20.118
	df	12	8	12	4	36	8	12
	Sig.	0.149	.000*	0.257	.001*	0.357	0.332	0.065
Industriousness	Chi-square	9.910	14.497	19.393	4.775	22.930	11.856	17.828
	df	12	8	12	4	36	8	12
	Sig.	0.624	0.07	0.079	0.311	0.955	0.158	0.121
Initiative	Chi-square	10.659	8.620	13.997	5.180	16.556	9.247	11.229
	df	12	8	12	4	36	8	12
	Sig.	0.558	0.375	0.301	0.269	0.998	0.322	0.509
Competence	Chi-square	10.852	11.294	22.110	9.526	21.058	15.315	23.152
	df	12	8	12	4	36	8	12
	Sig.	0.542	0.186	.036*	.049*	0.978	0.053	.026*
Commitment	Chi-square	4.621	8.916	10.830	6.000	22.252	12.710	8.645
	df	12	8	12	4	36	8	12
	Sig.	0.969	0.349	0.544	0.199	0.965	0.122	0.733
Selflessness	Chi-square	5.132	5.864	17.552	8.917	33.560	3.048	13.870
	df	12	8	12	4	36	8	12
	Sig.	0.953	0.662	0.13	0.063	0.585	0.931	0.309
High ethical standards	Chi-square	20.328	13.560	24.208	13.017	11.673	6.607	24.993
	df	12	8	12	4	36	8	12
	Sig.	0.061	0.094	.019*	.011*	1	0.58	.015*

Item Description		What is your present age group?	What is your associated gender?	What is your associated race?	Professionally registered member of ECSA?	Which engineering discipline do you work within?	Are you employed within the public or private sector?	Experience within the engineering profession?
Adaptability	Chi-square	12.398	10.844	34.140	7.756	18.091	17.342	24.652
	df	12	8	12	4	36	8	12
	Sig.	0.414	0.211	.001*	0.101	0.994	.027*	.017*
Communication skills	Chi-square	12.296	186.405	24.307	6.098	15.543	5.681	23.348
	df	12	8	12	4	36	8	12
	Sig.	0.422	.000*	.018*	0.192	0.999	0.683	.025*
Discipline	Chi-square	8.191	16.940	28.382	6.406	29.928	9.902	23.194
	df	12	8	12	4	36	8	12
	Sig.	0.77	.031*	.005*	0.171	0.752	0.272	.026*
Confidence	Chi-square	7.051	74.222	11.084	4.833	26.310	7.972	18.432
	df	12	8	12	4	36	8	12
	Sig.	0.854	.000*	0.522	0.305	0.882	0.436	0.103
Courage	Chi-square	11.860	64.756	15.441	3.400	20.430	4.216	10.561
	df	12	8	12	4	36	8	12
	Sig.	0.457	.000*	0.218	0.493	0.983	0.837	0.567
Curiosity	Chi-square	14.170	20.478	15.240	0.680	21.289	6.760	11.944
	df	12	8	12	4	36	8	12
	Sig.	0.29	.009*	0.229	0.954	0.975	0.563	0.45
Persistence	Chi-square	11.927	17.907	10.748	2.745	28.820	14.760	11.516
	df	12	8	12	4	36	8	12
	Sig.	0.452	.022*	0.551	0.601	0.797	0.064	0.485
* sig. values (p-values) less than 0.05								

Source: Author.

Table 4.20 illustrates the level of association of respondent's demographics with their awareness of ELE and their perceived level of Engineering Leadership competence in current graduates, locally.

Table 4.20: Cross-tabulation of demographics with Engineering Leadership awareness/competence

Item Description		**What is your present age group?**	**What is your associated gender?**	**What is your associated race?**	**Professionally registered member of ECSA?**	**Which engineering discipline do you work within?**	**Are you employed within the public or private sector?**	**Experience within the engineering profession?**
Did you know that Engineering Leadership can be developed (taught and learned) at undergraduate level?	Chi-square	2.743	5.001	7.272	0.892	4.802	2.817	3.946
	df	3	2	3	1	9	2	3
	Sig.	0.433	0.082	0.064	0.345	0.851	0.244	0.267
How do you rate the current level of KNOWLEDGE possessed by most recently graduated engineers, from local universities, with regards to the topic of Engineering Leadership?	Chi-square	52.840	2.861	8.295	7.678	27.478	6.167	25.645
	df	12	8	12	4	36	8	12
	Sig.	.000*	0.943	0.762	0.104	0.845	0.629	.012*
How do you rate the current level of COMPETENCE possessed by most recently graduate engineers, from local universities, with regards to Engineering Leadership implementation at work?	Chi-square	21.998	2.668	7.454	4.756	49.816	3.847	19.615
	df	12	8	12	4	36	8	12
	Sig.	.038*	0.953	0.826	0.313	0.063	0.871	0.075
* sig. values (p-values) less than 0.05								

Source: Author.

Table 4.21 illustrates the level of association of respondent's demographics with the perceived Engineering Leadership competency shortfalls in current undergraduate engineers.

Table 4.21: Cross-tabulation of demographics with Engineering Leadership competency shortfalls

Item Description		What is your present age group?	What is your associated gender?	What is your associated race?	Professionally registered member of ECSA?	Which engineering discipline do you work within?	Are you employed within the public or private sector?	Experience within the engineering profession?
Engineering knowledge	Chi-square	12.783	10.865	9.908	5.696	64.537	13.077	12.727
	df	12	8	12	4	36	8	12
	Sig.	0.385	0.209	0.624	0.223	.002*	0.109	0.389
Written and oral communication skills	Chi-square	42.699	45.330	13.523	23.373	36.789	15.742	30.429
	df	12	8	12	4	36	8	12
	Sig.	.000*	.000*	0.332	.000*	0.432	.046*	.002*
Client/customer relations skills	Chi-square	13.365	6.802	21.374	7.111	23.609	8.463	16.058
	df	12	8	12	4	36	8	12
	Sig.	0.343	0.558	.045*	0.13	0.944	0.39	0.189
Personal initiative	Chi-square	15.090	6.346	12.741	10.632	25.210	6.679	12.551
	df	12	8	12	4	36	8	12
	Sig.	0.237	0.609	0.388	.031*	0.911	0.572	0.403
Industry/ organisational knowledge	Chi-square	11.172	6.979	8.607	9.642	34.998	7.552	8.047
	df	12	8	12	4	36	8	12
	Sig.	0.514	0.539	0.736	.047*	0.516	0.478	0.781
Decision making skills	Chi-square	42.658	14.155	15.633	16.583	35.615	4.242	21.539
	df	12	8	12	4	36	8	12
	Sig.	.000*	0.078	0.209	.002*	0.487	0.835	.043*
Self-management	Chi-square	31.648	6.265	19.327	13.490	59.531	9.927	34.298
	df	12	8	12	4	36	8	12
	Sig.	.002*	0.618	0.081	.009*	.008*	0.27	.001*
Problem solving skills	Chi-square	26.262	8.265	15.104	16.188	56.876	16.493	40.550
	df	12	8	12	4	36	8	12
	Sig.	.010*	0.408	0.236	.003*	.015*	.036*	.000*

Item Description		What is your present age group?	What is your associated gender?	What is your associated race?	Professionally registered member of ECSA?	Which engineering discipline do you work within?	Are you employed within the public or private sector?	Experience within the engineering profession?
Ability to assess risk	Chi-square	12.507	11.842	11.867	8.990	30.441	9.114	8.901
	df	12	8	12	4	36	8	12
	Sig.	0.406	0.158	0.456	0.061	0.73	0.333	0.711
Sense of urgency and will to deliver on time	Chi-square	22.873	14.182	9.558	8.341	47.193	3.936	19.922
	df	12	8	12	4	36	8	12
	Sig.	.029*	0.077	0.655	0.08	0.1	0.863	0.069
Resourcefulness and flexibility	Chi-square	20.397	16.088	14.430	5.142	56.287	8.514	15.928
	df	12	8	12	4	36	8	12
	Sig.	0.06	.041*	0.274	0.273	.017*	0.385	0.195
Trust and loyalty in a team setting	Chi-square	26.410	9.541	18.433	13.818	29.856	7.010	28.163
	df	12	8	12	4	36	8	12
	Sig.	.009*	0.299	0.103	.008*	0.755	0.536	.005*
Ability to relate to others	Chi-square	30.079	9.563	25.591	10.744	51.377	4.628	29.253
	df	12	8	12	4	36	8	12
	Sig.	.003*	0.297	.012*	.030*	.046*	0.796	.004*
General knowledge	Chi-square	21.422	6.693	11.942	16.301	61.862	12.157	20.531
	df	12	8	12	4	36	8	12
	Sig.	.045*	0.57	0.45	.003*	.005*	0.144	0.058
Quality orientated	Chi-square	26.377	10.260	7.935	23.351	56.287	11.934	31.116
	df	12	8	12	4	36	8	12
	Sig.	.009*	0.247	0.79	.000*	.017*	0.154	.002*
Creativity and Innovation	Chi-square	15.821	18.810	11.302	3.319	48.061	20.886	24.216
	df	12	8	12	4	36	8	12
	Sig.	0.2	.016*	0.503	0.506	0.086	.007*	.019*
Planning skills	Chi-square	25.766	8.280	17.729	9.291	29.569	15.554	20.972
	df	12	8	12	4	36	8	12
	Sig.	.012*	0.407	0.124	0.054	0.767	.049*	0.051
* sig. values (p-values) less than 0.05								

Source: Author.

Table 4.22 illustrates the level of association of respondent's demographics when assessing the desire and extent of future ELE implementation, locally.

Table 4.22: Cross-tabulation of demographics with the desire for ELE and the extent of implementation

Item Description		What is your present age group?	What is your associated gender?	What is your associated race?	Professionally registered member of ECSA?	Which engineering discipline do you work within?	Are you employed within the public or private sector?	Experience within the engineering profession?
Do you believe that Engineering Leadership Education should be incorporated into South African tertiary education institutions?	Chi-square	0.616	9.854	3.987	0.484	4.822	3.082	0.671
	df	3	2	3	1	9	2	3
	Sig.	0.893	.007*	0.263	0.487	0.85	0.214	0.88
Which approach to any newly implemented Engineering Leadership Education do you believe would be best suited to engineering undergraduate programmes in South Africa?	Chi-square	4.348	0.953	4.615	2.379	7.285	9.038	3.202
	df	3	2	3	1	9	2	3
	Sig.	0.226	0.621	0.202	0.123	0.607	.011*	0.361
* sig. values (p-values) less than 0.05								

Source: Author.

Table 4.23 illustrates the level of association of respondent's demographics with how much attention future ELE programmes should give to the specific aims/goals, locally.

Table 4.23: Cross-tabulation of demographics with specific aims/goals of ELE programmes

Item Description		**What is your present age group?**	**What is your associated gender?**	**What is your associated race?**	**Professionally registered member of ECSA?**	**Which engineering discipline do you work within?**	**Are you employed within the public or private sector?**	**Experience within the engineering profession?**
Development of leadership skills	Chi-square	7.287	12.095	30.469	8.620	31.606	10.533	10.278
	df	12	8	12	4	36	8	12
	Sig.	0.838	0.147	.002*	0.071	0.678	0.23	0.592
Development of managerial (administrative) skills	Chi-square	11.340	2.986	27.879	7.408	38.230	15.527	13.080
	df	12	8	12	4	36	8	12
	Sig.	0.5	0.935	.006*	0.116	0.368	.050*	0.363
Improved understanding of business concepts	Chi-square	9.777	3.061	17.824	18.512	23.827	9.171	18.149
	df	12	8	12	4	36	8	12
	Sig.	0.636	0.93	0.121	.001*	0.94	0.328	0.111
Development of entrepreneurial skills	Chi-square	11.368	17.471	52.353	21.421	28.610	3.214	24.365
	df	12	8	12	4	36	8	12
	Sig.	0.498	.026*	.000*	.000*	0.805	0.92	.018*
Improved skills in current technology	Chi-square	9.649	3.426	25.945	5.144	46.982	6.939	9.707
	df	12	8	12	4	36	8	12
	Sig.	0.647	0.905	.011*	0.273	0.104	0.543	0.642
Improved ability to solve business challenges	Chi-square	7.077	3.694	34.801	6.922	33.058	10.412	15.751
	df	12	8	12	4	36	8	12
	Sig.	0.852	0.884	.001*	0.14	0.609	0.237	0.203
Improved interpersonal skills	Chi-square	18.353	5.992	17.543	8.548	20.352	2.619	14.978
	df	12	8	12	4	36	8	12
	Sig.	0.105	0.648	0.13	0.073	0.983	0.956	0.243
Improve ethical leadership	Chi-square	7.636	4.463	13.476	3.773	12.864	9.245	9.975
	df	12	8	12	4	36	8	12
	Sig.	0.813	0.813	0.335	0.438	1	0.322	0.618

Item Description		What is your present age group?	What is your associated gender?	What is your associated race?	Professionally registered member of ECSA?	Which engineering discipline do you work within?	Are you employed within the public or private sector?	Experience within the engineering profession?
Improve visionary leadership	Chi-square	3.742	5.571	30.950	7.462	34.120	6.151	12.955
	df	12	8	12	4	36	8	12
	Sig.	0.988	0.695	.002*	0.113	0.558	0.63	0.372
Improve industry leadership	Chi-square	5.055	5.688	34.546	4.132	27.014	2.659	16.012
	df	12	8	12	4	36	8	12
	Sig.	0.956	0.682	.001*	0.388	0.86	0.954	0.191
Improve project management skills	Chi-square	6.192	14.707	33.347	7.310	27.699	20.305	20.285
	df	12	8	12	4	36	8	12
	Sig.	0.906	0.065	.001*	0.12	0.838	.009*	0.062
Develop desire for a positive impact on world challenges	Chi-square	28.965	14.558	41.213	36.180	42.056	3.981	44.943
	df	12	8	12	4	36	8	12
	Sig.	.004*	0.068	.000*	.000*	0.225	0.859	.000*
Develop ability to obtain team effectiveness	Chi-square	7.732	11.468	10.697	7.012	21.858	9.714	20.239
	df	12	8	12	4	36	8	12
	Sig.	0.806	0.177	0.555	0.135	0.969	0.286	0.063
Develop ability to engage others	Chi-square	6.303	18.461	11.098	3.460	24.148	7.848	10.947
	df	12	8	12	4	36	8	12
	Sig.	0.9	.018*	0.521	0.484	0.934	0.448	0.533
Develop personal awareness and growth	Chi-square	15.372	23.248	27.381	5.828	46.250	11.519	17.505
	df	12	8	12	4	36	8	12
	Sig.	0.222	.003*	.007*	0.212	0.118	0.174	0.132
Develop desire for demonstrating excellence	Chi-square	8.134	34.374	10.270	7.556	21.267	3.149	12.259
	df	12	8	12	4	36	8	12
	Sig.	0.775	.000*	0.592	0.109	0.976	0.925	0.425
* sig. values (p-values) less than 0.05								

Source: Author.

Table 4.24 illustrates the level of association of respondent's demographics with how much attention future ELE programmes should give to the specific themes, locally.

Table 4.24: Cross-tabulation of demographics with specific themes of ELE programmes

Item Description		**What is your present age group?**	**What is your associated gender?**	**What is your associated race?**	**Professionally registered member of ECSA?**	**Which engineering discipline do you work within?**	**Are you employed within the public or private sector?**	**Experience within the engineering profession?**
Understanding of leadership theory and practice	Chi-square	8.541	9.267	33.750	3.752	38.168	3.767	16.529
	df	12	8	12	4	36	8	12
	Sig.	0.742	0.32	.001*	0.441	0.371	0.878	0.168
Understanding of business fundamentals	Chi-square	10.198	24.423	22.022	2.661	24.059	7.778	16.952
	df	12	8	12	4	36	8	12
	Sig.	0.599	.002*	.037*	0.616	0.936	0.455	0.151
Development of project management knowledge and skills	Chi-square	9.363	14.706	30.679	5.654	28.879	8.858	18.408
	df	12	8	12	4	36	8	12
	Sig.	0.672	0.065	.002*	0.227	0.794	0.354	0.104
Development of negotiation knowledge and skills	Chi-square	10.308	12.975	22.023	2.619	57.127	9.395	9.249
	df	12	8	12	4	36	8	12
	Sig.	0.589	0.113	.037*	0.624	.014*	0.31	0.682
Development of career management knowledge and skills	Chi-square	27.020	6.654	24.691	4.823	30.664	15.656	19.706
	df	12	8	12	4	36	8	12
	Sig.	.008*	0.574	.016*	0.306	0.72	.048*	0.073
Development of presentation knowledge and skills	Chi-square	8.882	8.396	18.347	2.091	33.496	3.962	7.620
	df	12	8	12	4	36	8	12
	Sig.	0.713	0.396	0.106	0.719	0.588	0.861	0.814
Development of teamwork knowledge and skills	Chi-square	10.390	22.279	16.780	4.392	31.772	1.393	12.777
	df	12	8	12	4	36	8	12
	Sig.	0.582	.004*	0.158	0.356	0.67	0.994	0.385
Development of self-awareness	Chi-square	20.100	13.960	24.544	14.094	37.328	13.282	21.940

Item Description		What is your present age group?	What is your associated gender?	What is your associated race?	Professionally registered member of ECSA?	Which engineering discipline do you work within?	Are you employed within the public or private sector?	Experience within the engineering profession?
and emotional intelligence knowledge and skills	df	12	8	12	4	36	8	12
	Sig.	0.065	0.083	.017*	.007*	0.408	0.102	.038*
Development of conflict management knowledge and skills	Chi-square	11.184	24.342	15.974	7.004	37.520	6.032	13.964
	df	12	8	12	4	36	8	12
	Sig.	0.513	.002*	0.192	0.136	0.399	0.644	0.303
Training in how to effectively lead and motivate	Chi-square	10.485	8.943	21.533	6.688	44.069	4.589	11.733
	df	12	8	12	4	36	8	12
	Sig.	0.573	0.347	.043*	0.153	0.167	0.8	0.467
Training in ethics in engineering	Chi-square	8.359	13.220	7.851	4.651	31.702	14.280	15.896
	df	12	8	12	4	36	8	12
	Sig.	0.756	0.104	0.797	0.325	0.673	0.075	0.196
Development of public relations knowledge and skills	Chi-square	16.937	12.004	38.568	5.328	49.440	9.633	19.670
	df	12	8	12	4	36	8	12
	Sig.	0.152	0.151	.000*	0.255	0.067	0.292	0.074
Training in communication skills	Chi-square	6.467	13.301	8.575	5.316	18.889	7.299	16.892
	df	12	8	12	4	36	8	12
	Sig.	0.891	0.102	0.739	0.256	0.992	0.505	0.154
Training in managing interdisciplinary engineering teams	Chi-square	12.077	22.474	18.059	6.061	34.002	5.532	20.571
	df	12	8	12	4	36	8	12
	Sig.	0.44	.004*	0.114	0.195	0.564	0.699	0.057
Development of innovation knowledge and skills	Chi-square	15.424	49.528	47.833	14.277	32.851	7.027	24.379
	df	12	8	12	4	36	8	12
	Sig.	0.219	.000*	.000*	.006*	0.619	0.534	.018*
Development of public policy knowledge and skills	Chi-square	14.948	10.633	56.832	21.165	72.656	5.071	28.077
	df	12	8	12	4	36	8	12
	Sig.	0.244	0.223	.000*	.000*	.000*	0.75	.005*
Training in finance, marketing and investment	Chi-square	12.890	11.213	41.233	15.097	71.106	5.755	31.935
	df	12	8	12	4	36	8	12
	Sig.	0.377	0.19	.000*	.005*	.000*	0.675	.001*

Item Description		What is your present age group?	What is your associated gender?	What is your associated race?	Professionally registered member of ECSA?	Which engineering discipline do you work within?	Are you employed within the public or private sector?	Experience within the engineering profession?
Training in working effectively with others	Chi-square	7.354	7.408	21.508	4.689	19.880	6.290	11.483
	df	12	8	12	4	36	8	12
	Sig.	0.833	0.493	.043*	0.321	0.986	0.615	0.488
* sig. values (p-values) less than 0.05								

Source: Author.

Table 4.25 illustrates the level of association of respondent's demographics with how much attention future ELE programmes should give to the specific approaches/methods, locally.

Table 4.25: Cross-tabulation of demographics with specific approaches/ methods of ELE programmes

Item Description		**What is your present age group?**	**What is your associated gender?**	**What is your associated race?**	**Professionally registered member of ECSA?**	**Which engineering discipline do you work within?**	**Are you employed within the public or private sector?**	**Experience within the engineering profession?**
Leadership coursework/ modules	Chi-square	6.401	5.408	23.374	2.590	29.772	12.220	16.925
	df	12	8	12	4	36	8	12
	Sig.	0.895	0.713	.025*	0.629	0.758	0.142	0.152
Leadership workshops/ seminars	Chi-square	9.043	11.208	32.840	11.949	31.584	4.480	18.589
	df	12	8	12	4	36	8	12
	Sig.	0.699	0.19	.001*	.018*	0.679	0.811	0.099
Team learning/ scale projects	Chi-square	11.366	21.793	17.592	7.965	36.568	6.916	17.685
	df	12	8	12	4	36	8	12
	Sig.	0.498	.005*	0.129	0.093	0.442	0.546	0.126
Industry vacation work experience	Chi-square	5.028	4.447	7.596	6.657	37.621	19.020	8.008
	df	12	8	12	4	36	8	12
	Sig.	0.957	0.815	0.816	0.155	0.395	.015*	0.785
Peer/ faculty/ industry mentoring programmes	Chi-square	17.565	13.587	22.073	10.928	31.002	7.709	25.061
	df	12	8	12	4	36	8	12
	Sig.	0.13	0.093	.037*	.027*	0.705	0.462	.015*
Leadership reflection journals / personal portfolios	Chi-square	13.741	14.145	48.936	11.990	58.116	5.275	14.459
	df	12	8	12	4	36	8	12
	Sig.	0.318	0.078	.000*	.017*	.011*	0.728	0.272
Personal leadership development plan(s) with mentor	Chi-square	12.962	6.264	29.671	12.842	23.552	14.974	10.929
	df	12	8	12	4	36	8	12
	Sig.	0.372	0.618	.003*	.012*	0.945	0.06	0.535
Coordinated Networking opportunities with leaders	Chi-square	14.057	14.296	37.907	29.506	43.209	1.448	18.546
	df	12	8	12	4	36	8	12
	Sig.	0.297	0.074	.000*	.000*	0.19	0.994	0.1

Item Description		What is your present age group?	What is your associated gender?	What is your associated race?	Professionally registered member of ECSA?	Which engineering discipline do you work within?	Are you employed within the public or private sector?	Experience within the engineering profession?
On campus/ Community leadership opportunities	Chi-square	13.555	16.479	48.766	17.066	24.921	8.493	25.159
	df	12	8	12	4	36	8	12
	Sig.	0.33	.036*	.000*	.002*	0.918	0.387	.014*
* sig. values (p-values) less than 0.05								

Source: Author.

4.5.4 Correlation of Results

The following section provides results of the analysis carried out to identify possible correlations between individual items within scored groups. The Spearman's rank-order correlation coefficient indicates a high positive value for a strong and directly proportional association of two variables. Conversely, a negative coefficient would indicate an inverse association, with associated magnitude. All significant correlations are indicated with a single or double asterisk (*) for the 0.05 and 0.01 level of significance, respectively.

Table 4.26 illustrates the strength and direction of correlation between individual items when testing how important the specific Engineering Leadership responsibilities are to respondent's engineering work.

Table 4.26: Correlations of specific Engineering Leadership responsibilities

	Item Description		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	Being able to develop and engage others in a common vision	Correlation Coefficient	1.000							
		Sig. (2-tailed)								
2	Clearly planning and organising resources	Correlation Coefficient	.430**	1.000						
		Sig. (2-tailed)	0.000							
3	Developing and maintaining trust	Correlation Coefficient	.315**	.381**	1.000					
		Sig. (2-tailed)	0.000	0.000						
4	Sharing perspectives	Correlation Coefficient	.453**	.352**	.539**	1.000				
		Sig. (2-tailed)	0.000	0.000	0.000					
5	Inspiring creativity	Correlation Coefficient	.425**	.318**	.395**	.653**	1.000			
		Sig. (2-tailed)	0.000	0.000	0.000	0.000				
6	Heightening motivation	Correlation Coefficient	.388**	.386**	.434**	.556**	.637**	1.000		
		Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000			
7	Being sensitive to competing needs	Correlation Coefficient	.341**	.413**	.378**	.517**	.492**	.565**	1.000	
		Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000		
8	Upholding and leading good ethical behaviour	Correlation Coefficient	.318**	.307**	.452**	.364**	.362**	.374**	.421**	1.000
		Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
* sig. values (p-values) less than 0.05 ** sig. values (p-values) less than 0.01										

Source: Author.

Table 4.27 illustrates the strength and direction of correlation between individual items when testing how important the specific Engineering Leadership principles are to respondent's engineering work.

Table 4.27: Correlations of specific Engineering Leadership principles

Item Description			1	2	3	4	5	6	7
1	Being technically competent	Correlation Coefficient	1,000						
		Sig. (2-tailed)							
2	Knowing oneself (abilities) and seeking self-improvement	Correlation Coefficient	.342**	1,000					
		Sig. (2-tailed)	0,000						
3	Making sound and timely decisions	Correlation Coefficient	.271**	.436**	1,000				
		Sig. (2-tailed)	0,000	0,000					
4	Setting the example	Correlation Coefficient	.247**	.407**	.565**	1,000			
		Sig. (2-tailed)	0,000	0,000	0,000				
5	Seeking responsibility and taking responsibility for one's actions	Correlation Coefficient	.223**	.410**	.377**	.560**	1,000		
		Sig. (2-tailed)	0,000	0,000	0,000	0,000			
6	Communicating with and developing subordinates both as individuals and as a team	Correlation Coefficient	.131*	.415**	.480**	.499**	.454**	1,000	
		Sig. (2-tailed)	0,016	0,000	0,000	0,000	0,000		
7	Ensuring that a project is understood, supervised and accomplished	Correlation Coefficient	.274**	.309**	.481**	.404**	.440**	.497**	1,000
		Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000	
* sig. values (p-values) less than 0.05 ** sig. values (p-values) less than 0.01									

Source: Author.

Table 4.28(a) and its extension, Table 4.28(b), illustrate the strength and direction of correlation between individual items when testing how important the specific Engineering Leadership qualities/attributes are to respondent's engineering work.

Table 4.28(a): Correlations of specific Engineering Leadership qualities/ attributes

Item Description			1	2	3	4	5	6	7	8
1	Vision	Correlation Coefficient	1,000							
		Sig. (2-tailed)								
2	Enthusiasm	Correlation Coefficient	.527**	1,000						
		Sig. (2-tailed)	0,000							
3	Industriousness	Correlation Coefficient	.346**	.530**	1,000					
		Sig. (2-tailed)	0,000	0,000						
4	Initiative	Correlation Coefficient	.431**	.492**	.494**	1,000				
		Sig. (2-tailed)	0,000	0,000	0,000					
5	Competence	Correlation Coefficient	.264**	.215**	.212**	.358**	1,000			
		Sig. (2-tailed)	0,000	0,000	0,000	0,000				
6	Commitment	Correlation Coefficient	.355**	.425**	.347**	.449**	.410**	1,000		
		Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000			
7	Selflessness	Correlation Coefficient	.489**	.510**	.433**	.429**	.252**	.436**	1,000	
		Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000		
8	High ethical standards	Correlation Coefficient	.366**	.342**	.193**	.354**	.305**	.262**	.414**	1,000
		Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000	0,000	
9	Adaptability	Correlation Coefficient	.306**	.395**	.425**	.409**	.190**	.405**	.372**	.296**
		Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
10	Communication skills	Correlation Coefficient	.329**	.261**	.267**	.323**	.237**	.335**	.265**	.239**
		Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
11	Discipline	Correlation Coefficient	.373**	.421**	.370**	.406**	.301**	.515**	.485**	.410**
		Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
12	Confidence	Correlation Coefficient	.362**	.403**	.400**	.476**	.272**	.387**	.419**	.179**
		Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,001
13	Courage	Correlation Coefficient	.450**	.460**	.407**	.500**	.180**	.423**	.491**	.270**
		Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,001	0,000	0,000	0,000
14	Curiosity	Correlation Coefficient	.402**	.423**	.385**	.398**	.232**	.308**	.401**	.312**

Item Description			1	2	3	4	5	6	7	8
		Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
15	Persistence	Correlation Coefficient	.371**	.486**	.435**	.428**	.228**	.418**	.399**	.335**
		Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
* sig. values (p-values) less than 0.05 ** sig. values (p-values) less than 0.01										

Source: Author.

Table 4.28(b): Correlations of specific Engineering Leadership qualities/ attributes (continued)

Item Description			9	10	11	12	13	14	15
9	Adaptability	Correlation Coefficient	1,000						
		Sig. (2-tailed)							
10	Communication skills	Correlation Coefficient	.444**	1,000					
		Sig. (2-tailed)	0,000						
11	Discipline	Correlation Coefficient	.437**	.421**	1,000				
		Sig. (2-tailed)	0,000	0,000					
12	Confidence	Correlation Coefficient	.429**	.429**	.557**	1,000			
		Sig. (2-tailed)	0,000	0,000	0,000				
13	Courage	Correlation Coefficient	.417**	.379**	.488**	.714**	1,000		
		Sig. (2-tailed)	0,000	0,000	0,000	0,000			
14	Curiosity	Correlation Coefficient	.389**	.322**	.435**	.532**	.615**	1,000	
		Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000		
15	Persistence	Correlation Coefficient	.421**	.378**	.460**	.473**	.597**	.616**	1,000
		Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000	
* sig. values (p-values) less than 0.05 ** sig. values (p-values) less than 0.01									

Source: Author.

Table 4.29(a) and its extension, Table 4.29(b), illustrate the strength and direction of correlation between individual items when testing the perceived level of Engineering Leadership competency shortfall in current graduates.

Table 4.29(a): Correlations of specific Engineering Leadership competency shortfalls

Item Description			1	2	3	4	5	6	7	8
1	Engineering knowledge	Correlation Coefficient	1,000							
		Sig. (2-tailed)								
2	Written and oral communication skills	Correlation Coefficient	.508**	1,000						
		Sig. (2-tailed)	0,000							
3	Client/customer relations skills	Correlation Coefficient	.180**	.398**	1,000					
		Sig. (2-tailed)	0,001	0,000						
4	Personal initiative	Correlation Coefficient	.283**	.368**	.373**	1,000				
		Sig. (2-tailed)	0,000	0,000	0,000					
5	Industry/organisational knowledge	Correlation Coefficient	.223**	.197**	.442**	.366**	1,000			
		Sig. (2-tailed)	0,000	0,000	0,000	0,000				
6	Decision making skills	Correlation Coefficient	.256**	.399**	.440**	.414**	.494**	1,000		
		Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000			
7	Self-management	Correlation Coefficient	.197**	.358**	.323**	.382**	.351**	.580**	1,000	
		Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000		
8	Problem solving skills	Correlation Coefficient	.507**	.442**	.184**	.384**	.254**	.442**	.498**	1,000
		Sig. (2-tailed)	0,000	0,000	0,001	0,000	0,000	0,000	0,000	
9	Ability to assess risk	Correlation Coefficient	.251**	.333**	.394**	.276**	.412**	.490**	.400**	.516**
		Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
10	Sense of urgency and will to deliver on time	Correlation Coefficient	.227**	.336**	.400**	.343**	.373**	.497**	.538**	.453**
		Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
11	Resourcefulness and flex bility	Correlation Coefficient	.262**	.321**	.269**	.404**	.309**	.421**	.479**	.511**
		Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
12	Trust and loyalty in a team setting	Correlation Coefficient	.217**	.306**	.268**	.398**	.207**	.333**	.416**	.400**
		Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
13	Ability to relate to others	Correlation Coefficient	.153**	.277**	.209**	.353**	.193**	.331**	.395**	.338**
		Sig. (2-tailed)	0,005	0,000	0,000	0,000	0,000	0,000	0,000	0,000

Item Description			1	2	3	4	5	6	7	8
14	General knowledge	Correlation Coefficient	.375**	.387**	.134*	.303**	.234**	.304**	.285**	.427**
		Sig. (2-tailed)	0,000	0,000	0,013	0,000	0,000	0,000	0,000	0,000
15	Quality orientated	Correlation Coefficient	.383**	.418**	.254**	.418**	.273**	.415**	.417**	.474**
		Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
16	Creativity and Innovation	Correlation Coefficient	.335**	.282**	.173**	.408**	.208**	.347**	.360**	.457**
		Sig. (2-tailed)	0,000	0,000	0,001	0,000	0,000	0,000	0,000	0,000
17	Planning skills	Correlation Coefficient	.297**	.346**	.260**	.328**	.327**	.425**	.468**	.479**
		Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
* sig. values (p-values) less than 0.05 ** sig. values (p-values) less than 0.01										

Source: Author.

Table 4.29(b): Correlations of specific Engineering Leadership competency shortfalls (continued)

Item Description			9	10	11	12	13	14	15	16	17
9	Ability to assess risk	Correlation Coefficient	1,000								
		Sig. (2-tailed)									
10	Sense of urgency and will to deliver on time	Correlation Coefficient	.514**	1,000							
		Sig. (2-tailed)	0,000								
11	Resourcefulness and flex bility	Correlation Coefficient	.456**	.669**	1,000						
		Sig. (2-tailed)	0,000	0,000							
12	Trust and loyalty in a team setting	Correlation Coefficient	.334**	.465**	.540**	1,000					
		Sig. (2-tailed)	0,000	0,000	0,000						
13	Ability to relate to others	Correlation Coefficient	.298**	.320**	.453**	.669**	1,000				
		Sig. (2-tailed)	0,000	0,000	0,000	0,000					
14	General knowledge	Correlation Coefficient	.300**	.293**	.386**	.343**	.444**	1,000			
		Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000				
15	Quality orientated	Correlation Coefficient	.419**	.537**	.489**	.431**	.420**	.550**	1,000		
		Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000			
16	Creativity and Innovation	Correlation Coefficient	.351**	.439**	.505**	.417**	.379**	.433**	.556**	1,000	
		Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000	0,000		
17	Planning skills	Correlation Coefficient	.489**	.485**	.428**	.351**	.324**	.371**	.552**	.528**	1,000
		Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	
* sig. values (p-values) less than 0.05 ** sig. values (p-values) less than 0.01											

Source: Author.

Table 4.30(a) and its extension, Table 4.30(b), illustrate the strength and direction of correlation between individual items when testing the desire for specific aims/goals for ELE programmes.

Table 4.30(a): Correlations of specific aims/goals to ELE programmes

Item Description			1	2	3	4	5	6	7	8
1	Development of leadership skills	Correlation Coefficient	1,000							
		Sig. (2-tailed)								
2	Development of managerial (administrative) skills	Correlation Coefficient	.598**	1,000						
		Sig. (2-tailed)	0,000							
3	Improved understanding of business concepts	Correlation Coefficient	.369**	.557**	1,000					
		Sig. (2-tailed)	0,000	0,000						
4	Development of entrepreneurial skills	Correlation Coefficient	.365**	.381**	.510**	1,000				
		Sig. (2-tailed)	0,000	0,000	0,000					
5	Improved skills in current technology	Correlation Coefficient	.307**	.319**	.311**	.303**	1,000			
		Sig. (2-tailed)	0,000	0,000	0,000	0,000				
6	Improved ability to solve business challenges	Correlation Coefficient	.505**	.473**	.571**	.511**	.376**	1,000		
		Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000			
7	Improved interpersonal skills	Correlation Coefficient	.520**	.378**	.371**	.385**	.330**	.532**	1,000	
		Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000		
8	Improve ethical leadership	Correlation Coefficient	.382**	.284**	.276**	.285**	.332**	.380**	.548**	1,000
		Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000	0,000	
9	Improve visionary leadership	Correlation Coefficient	.540**	.386**	.349**	.454**	.235**	.515**	.505**	.531**
		Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
10	Improve industry leadership	Correlation Coefficient	.518**	.473**	.445**	.441**	.326**	.578**	.498**	.470**
		Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
11	Improve project management skills	Correlation Coefficient	.372**	.432**	.358**	.283**	.302**	.396**	.313**	.354**
		Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
12	Develop desire for a positive impact on world challenges	Correlation Coefficient	.348**	.352**	.358**	.407**	.425**	.416**	.436**	.350**
		Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
13		Correlation Coefficient	.477**	.411**	.406**	.406**	.287**	.550**	.534**	.399**

Item Description			1	2	3	4	5	6	7	8
	Develop ability to obtain team effectiveness	Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
14	Develop ability to engage others	Correlation Coefficient	.479**	.381**	.381**	.368**	.244**	.467**	.631**	.401**
		Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
15	Develop personal awareness and growth	Correlation Coefficient	.399**	.320**	.316**	.342**	.360**	.377**	.532**	.403**
		Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
16	Develop desire for demonstrating excellence	Correlation Coefficient	.288**	.316**	.303**	.301**	.388**	.338**	.407**	.477**
		Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
* sig. values (p-values) less than 0.05 ** sig. values (p-values) less than 0.01										

Source: Author.

Table 4.30(b): Correlations of specific aims/goals to ELE programmes (continued)

Item Description			9	10	11	12	13	14	15	16
9	Improve visionary leadership	Correlation Coefficient	1,000							
		Sig. (2-tailed)								
10	Improve industry leadership	Correlation Coefficient	.726**	1,000						
		Sig. (2-tailed)	0,000							
11	Improve project management skills	Correlation Coefficient	.346**	.482**	1,000					
		Sig. (2-tailed)	0,000	0,000						
12	Develop desire for a positive impact on world challenges	Correlation Coefficient	.437**	.525**	.433**	1,000				
		Sig. (2-tailed)	0,000	0,000	0,000					
13	Develop ability to obtain team effectiveness	Correlation Coefficient	.495**	.549**	.389**	.573**	1,000			
		Sig. (2-tailed)	0,000	0,000	0,000	0,000				
14	Develop ability to engage others	Correlation Coefficient	.527**	.516**	.317**	.507**	.748**	1,000		
		Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000			
15	Develop personal awareness and growth	Correlation Coefficient	.459**	.439**	.328**	.521**	.553**	.611**	1,000	
		Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000		
16	Develop desire for demonstrating excellence	Correlation Coefficient	.377**	.335**	.320**	.483**	.480**	.426**	.605**	1,000
		Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,000	0,000	
* sig. values (p-values) less than 0.05 ** sig. values (p-values) less than 0.01										

Source: Author.

Table 4.31(a) and its extension, Table 4.31(b), illustrate the strength and direction of correlation between individual items when testing the desire for specific themes for ELE programmes.

Table 4.31(a): Correlations of specific themes to ELE programmes

Item Description			1	2	3	4	5	6	7	8	9
1	Understanding of leadership theory and practice	Correlation Coefficient	1.000								
		Sig. (2-tailed)									
2	Understanding of business fundamentals	Correlation Coefficient	.548**	1.000							
		Sig. (2-tailed)	0.000								
3	Development of project management knowledge and skills	Correlation Coefficient	.396**	.494**	1.000						
		Sig. (2-tailed)	0.000	0.000							
4	Development of negotiation knowledge and skills	Correlation Coefficient	.494**	.487**	.455**	1.000					
		Sig. (2-tailed)	0.000	0.000	0.000						
5	Development of career management knowledge and skills	Correlation Coefficient	.499**	.476**	.357**	.584**	1.000				
		Sig. (2-tailed)	0.000	0.000	0.000	0.000					
6	Development of presentation knowledge and skills	Correlation Coefficient	.381**	.453**	.475**	.495**	.481**	1.000			
		Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000				
7	Development of teamwork knowledge and skills	Correlation Coefficient	.491**	.461**	.437**	.492**	.581**	.616**	1.000		
		Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000			
8	Development of self-awareness and emotional intelligence knowledge and skills	Correlation Coefficient	.485**	.416**	.374**	.518**	.629**	.495**	.634**	1.000	
		Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000		
9	Development of conflict management knowledge and skills	Correlation Coefficient	.430**	.436**	.402**	.614**	.500**	.535**	.555**	.663**	1.000
		Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
10		Correlation Coefficient	.548**	.540**	.407**	.612**	.517**	.468**	.528**	.502**	.614**

Item Description			1	2	3	4	5	6	7	8	9
	Training in how to effectively lead and motivate	Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
11	Training in ethics in engineering	Correlation Coefficient	.318**	.368**	.274**	.357**	.403**	.399**	.431**	.411**	.422**
		Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12	Development of public relations knowledge and skills	Correlation Coefficient	.545**	.499**	.411**	.629**	.567**	.513**	.593**	.582**	.594**
		Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
13	Training in communication skills	Correlation Coefficient	.387**	.431**	.416**	.456**	.453**	.557**	.568**	.510**	.525**
		Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14	Training in managing interdisciplinary engineering teams	Correlation Coefficient	.454**	.529**	.416**	.490**	.469**	.472**	.561**	.520**	.520**
		Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15	Development of innovation knowledge and skills	Correlation Coefficient	.475**	.437**	.362**	.435**	.497**	.478**	.548**	.464**	.425**
		Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16	Development of public policy knowledge and skills	Correlation Coefficient	.477**	.478**	.429**	.493**	.524**	.511**	.518**	.475**	.463**
		Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
17	Training in finance, marketing and investment	Correlation Coefficient	.489**	.574**	.373**	.531**	.526**	.450**	.462**	.463**	.429**
		Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
18	Training in working effectively with others	Correlation Coefficient	.468**	.439**	.390**	.515**	.521**	.519**	.661**	.606**	.558**
		Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
* sig. values (p-values) less than 0.05 ** sig. values (p-values) less than 0.01											

Source: Author.

Table 4.31(b): Correlations of specific themes to ELE programmes (continued)

Item Description			10	11	12	13	14	15	16	17	18
10	Training in how to effectively lead and motivate	Correlation Coefficient	1.000								
		Sig. (2-tailed)									
11	Training in ethics in engineering	Correlation Coefficient	.421**	1.000							
		Sig. (2-tailed)	0.000								
12	Development of public relations knowledge and skills	Correlation Coefficient	.589**	.510**	1.000						
		Sig. (2-tailed)	0.000	0.000							
13	Training in communication skills	Correlation Coefficient	.478**	.396**	.608**	1.000					
		Sig. (2-tailed)	0.000	0.000	0.000						
14	Training in managing interdisciplinary engineering teams	Correlation Coefficient	.542**	.329**	.565**	.537**	1.000				
		Sig. (2-tailed)	0.000	0.000	0.000	0.000					
15	Development of innovation knowledge and skills	Correlation Coefficient	.518**	.379**	.520**	.466**	.504**	1.000			
		Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000				
16	Development of public policy knowledge and skills	Correlation Coefficient	.529**	.396**	.642**	.525**	.579**	.615**	1.000		
		Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000			
17	Training in finance, marketing and investment	Correlation Coefficient	.469**	.333**	.568**	.417**	.505**	.502**	.604**	1.000	
		Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000		
18	Training in working effectively with others	Correlation Coefficient	.547**	.429**	.626**	.596**	.561**	.514**	.519**	.512**	1.000
		Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	

* sig. values (p-values) less than 0.05

** sig. values (p-values) less than 0.01

Source: Author.

Table 4.32 illustrates the strength and direction of correlation between individual items when testing the desire for specific approaches/methods to ELE programmes.

Table 4.32: Correlation of specific approaches/methods to ELE programmes

Item Description			1	2	3	4	5	6	7	8	9
1	Leadership coursework/modules	Correlation Coefficient	1.000								
		Sig. (2-tailed)									
2	Leadership workshops/seminars	Correlation Coefficient	.576**	1.000							
		Sig. (2-tailed)	0.000								
3	Team learning/scale projects	Correlation Coefficient	.559**	.486**	1.000						
		Sig. (2-tailed)	0.000	0.000							
4	Industry vacation work experience	Correlation Coefficient	.244**	.252**	.376**	1.000					
		Sig. (2-tailed)	0.000	0.000	0.000						
5	Peer/ faculty/ industry mentoring programmes	Correlation Coefficient	.301**	.354**	.408**	.599**	1.000				
		Sig. (2-tailed)	0.000	0.000	0.000	0.000					
6	Leadership reflection journals / personal portfolios	Correlation Coefficient	.545**	.463**	.467**	.303**	.400**	1.000			
		Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000				
7	Personal leadership development plan(s) with mentor	Correlation Coefficient	.484**	.437**	.486**	.316**	.504**	.562**	1.000		
		Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000			
8	Coordinated Networking opportunities with leaders	Correlation Coefficient	.467**	.486**	.498**	.391**	.487**	.493**	.586**	1.000	
		Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000		
9	On campus/Community leadership opportunities	Correlation Coefficient	.447**	.541**	.533**	.348**	.476**	.564**	.532**	.609**	1.000
		Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
* sig. values (p-values) less than 0.05 ** sig. values (p-values) less than 0.01											

Source: Author

4.6 Conclusion

This chapter presented an extensive overview of the descriptive and inferential results of the study derived from the data collection and analysis procedures that were outlined in the preceding research methodology chapter. These results are further interpreted and discussed in the following chapter.

CHAPTER FIVE
Discussion of Results

5.1 Introduction

This chapter provides an explanation and discussion of the research survey's results which were presented in the previous chapter. Specific links between the results and the existing literature on the topic are explored. The statistical confidence and reliability are discussed and an interpretation of each surveyed section is undertaken, which includes: 1) the demographics; 2) the perceived value of specific leadership competencies; 3) the perceived level of current leadership competency and shortfalls/gaps in SA; and 4) any consensus regarding the future implementation of ELE locally and the preferred framework. The various analysis methods and results are interpreted systematically such that the collected data is able to yield as many useful deductions as possible, regarding the engineering industry's perspective of the topic of ELE.

5.2 Discussion of Descriptive Results

5.2.1 Study Response Rate, Confidence Level and Margin of Error

The overall response to the survey study was viewed as positive (90.16%) and representative of the target population. While the final total responses received were less than the targeted minimum sample size, the confidence level of the results was maintained, with a relatively small (0.31%) increase in the confidence interval.

5.2.2 Reliability of Results

All of the core questions tested as per Table 4.1 provide higher reliability coefficients than the benchmark Cronbach's Alpha score of 0.7. As such the results were viewed as reliable with the 'importance of Engineering Leadership principles' posing the largest risk (0.859) and the 'desire for specific themes within ELE programmes' offering the most certainty of the target population's views.

5.2.3 Section 1: Demographics

5.2.3.1 Age Profile of Respondents

The respondents were well distributed among the senior age groups with the majority 36% between 40 to 60 years of age and a further 29% over 60 years old. The majority senior response base was viewed as a positive factor as it indicated an experienced workforce and more informed viewpoint. There were no registration statistics available regarding the age profile of the ECSA membership for the year of the study to confirm the level of representation from the target population.

5.2.3.2 Associated Gender of Respondents

The gender profile of respondents was representative of ECSA's registration records. ECSA's (2018i: 85) most current available annual report indicated a male to female ratio of 12:1 in the professional category and 3:1 in the candidate category. An overall male to female ratio of approximately 4:1 (83%:16%) was realised in the survey results, depicting significantly more males in the sample, indicating a high possibility of gender bias.

5.2.3.3 Associated Race of Respondents

The race profile of respondents was also representative of ECSA's registration records and SA's historical employment backdrop, with a majority White participation (64%) followed by African (23%), Indian (8%) and Coloured (6%). ECSA's (2018i: 85) annual report indicated the racial composition within the professional category to be 69% White, 22% African, 7% Indian and 2% Coloured.

5.2.3.4 Engineering Discipline of Respondents

A significant portion of responses was received from the civil engineering discipline followed by industrial and electrical. The minority of responses remaining were from the other participating disciplines. These results were in line with ECSA's records which indicate that civil engineering is the most established discipline locally.

As all engineering disciplines have specific demands due to operating under varying circumstances and needs, the general results are expected to be skewed towards the needs of the civil engineering field. Further analysis of the data, which was not undertaken in this dissertation, may be carried out for discipline-specific preferences, where adequate sub-sample data is available.

5.2.3.5 Status of Professional Registration of Respondents

A majority 70% of respondents indicated that they were registered as professional engineers, technologists or technicians with ECSA. This was viewed as a positive outcome in that the majority of the sample has already had experience with the current and older registration systems, so they may be more able to critique aspects relating to them. ECSA (2018i: 85-88) reported that during the period of the study approximately 56% of the membership was professionally registered and the remaining 44% were candidate engineers. This indicates that there was possibly a greater interest from senior members of the industry for the study, in correlation with the results of the age profile.

5.2.3.6 Employment Sector of Respondents

The majority (73%) of respondents indicated that they worked within the private sector, consisting of consulting engineering companies, mining, production, and so forth. This implies that the results may be skewed towards a production and business-centred approach, over an administrative and regulatory one. There were no registration statistics available regarding the employment sector of the ECSA membership to confirm the level of representation from the target population.

5.2.3.7 Engineering Experience of Respondents

Over half of the respondents have worked within the engineering industry for more than 20 years. A further 22% have worked within the industry between 11 to 20 years. This assures that a mature and well-experienced industry viewpoint was derived from the results. There were no registration statistics available regarding the work experience of the ECSA membership to confirm the level of representation from the target population. A counter argument could be made that the senior response base may in some respects be out of touch with present and/or future needs.

5.2.4 Section 2: Perceived Value of Specific Engineering Leadership Competencies in SA

5.2.4.1 Engineering Leadership Responsibilities

Respondents ranked the specific Engineering Leadership responsibilities as illustrated in Figure 4.8. Of highest importance was ‘upholding and leading good ethical behaviour’. The result supported the ASCE’s (2008: 146) priority and call for ‘high ethical standards’ to be demonstrated by professional engineers.

From the factor analysis carried out as per Table 4.3, the engineering responsibilities tested all fell within a single theme/component. This indicated that the results were purely a statistical measure of the Engineering Leadership responsibilities theme/aspect.

The section analysis carried out as per Table 4.10 illustrated that all responses tested from the scoring of Engineering Leadership responsibilities were of high importance (> 3=reasonable importance) with a significant difference ($p<0.05$) between those who scored above to those who scored below.

Cross-tabulation of the demographics with the specific Engineering Leadership responsibilities indicated a significant relationship between registered members of ECSA and the highest ranked responsibility of ‘upholding and leading good ethical behaviour’. In this respect 76.7% of registered professionals and 71.8% of candidate engineers rated the aspect as ‘very important’. Other relationships relating to the biographical details were also identified as per Table 4.17.

A review of the results from the correlations analysis carried out, as tabulated in Table 4.26, illustrates that all the items tested within the group have a significant level of correlation to each other. This is based on the manner in which items were scored. All relationships were calculated to be directly proportional (positive).

5.2.4.2 Engineering Leadership Principles

Respondents ranked the specific Engineering Leadership principles as per Figure 4.9. Of highest importance was ‘ensuring that a project is understood, supervised and accomplished’. While it may be assumed at first that such a principle may only be developed through real world projects, the ASCE (2008: 145) specifically mentions that this development should begin at an undergraduate level through formal education.

From the factor analysis carried out as per Table 4.4, the engineering principles tested all fell within a single theme/component. This indicates that the results were purely a statistical measure of Engineering Leadership principles.

The section analysis carried out as per Table 4.11 illustrated that all responses tested from the scoring of Engineering Leadership principles were of high importance (> 3=reasonable importance) with a significant difference ($p<0.05$) between those who scored above to those who scored below.

Cross-tabulation of the demographics with the specific Engineering Leadership principles indicated significant relationships between the biographical characteristics of registered members of ECSA and/or their engineering experience with principles including ‘being technically competent’, ‘setting the example’, ‘seeking responsibility and taking responsibility for one’s actions’ and ‘ensuring that a project is understood, supervised and accomplished’. Other relationships relating to the biographical details were also identified as per Table 4.18.

A review of the results from the correlations analysis carried out, as tabulated in Table 4.27, illustrates that all the items tested within the group have a significant level of correlation to each other. This is based on the manner in which items were scored. All relationships were calculated to be directly proportional (positive).

5.2.4.3 Engineering Leadership Qualities/Attributes

Respondents ranked the specific Engineering Leadership qualities/attributes as per Figure 4.10. Of high importance was ‘engineering competence’, ‘high ethical standards’, ‘commitment’, ‘communication skills’, ‘discipline’, ‘initiative’, ‘adaptability’ and ‘persistence’. The ASCE (2008: 145) and Crumpton-Young, et al. (2010: 10) also maintain that proficient engineering knowledge, personal initiative and good communication skills, among others, are seen to be large contributing qualities and attributes to business and industry success.

From the factor analysis carried out as per Table 4.5 the engineering qualities/attributes tested were statistically, divided into two sub-themes/components. The first sub-theme comprised ‘vision’, ‘initiative’, ‘competence’, ‘commitment’, ‘high ethical standards’ and ‘communication skills’. The group was subjectively viewed as ‘fundamental leadership qualities/attributes’. The other sub-theme included ‘enthusiasm’, ‘industriousness’, ‘selflessness’, ‘adaptability’, ‘discipline’, ‘confidence’, ‘courage’, ‘curiosity’ and ‘persistence’. This second group was subjectively viewed as ‘enhancing leadership qualities/attributes’.

The section analysis carried out as per Table 4.12 illustrated that all responses tested from the scoring of Engineering Leadership qualities/attributes were of high importance (> 3=reasonable importance) with a significant difference ($p<0.05$) between those who scored above to those who scored below.

Cross-tabulation of the demographics with the specific Engineering Leadership qualities/attributes indicated significant relationships between registered members of ECSA and/or the respondents’ engineering experience with qualities/attributes including ‘vision’, ‘enthusiasm’, ‘engineering competence’, ‘high ethical standards’, ‘adaptability’ and ‘discipline’. Other relationships relating to the biographical details were also identified as per Table 4.19.

A review of the results from the correlations analysis carried out, as tabulated in Table 4.28(a) and Table 4.28(b), illustrates that all the items tested within the group have a significant level of correlation to each other. This is based on the manner in which items were scored. All relationships were calculated to be directly proportional (positive).

5.2.5 Section 3: Perceived Level of Engineering Leadership Competency in SA at Present

5.2.5.1 Awareness of ELE for Undergraduate Development

When asked if respondents were aware that Engineering Leadership could be ‘taught and learned’ at undergraduate level a relatively large percentage (44%) responded ‘No’, that they did not realise this, as per Figure 4.11. This result is in line with the findings of Graham, et al. (2009: 12) who recognised that no ELE programmes have historically been implemented in SA, with the present circumstances remaining unchanged.

Internationally, one can expect that more engineers are aware of ELE as engineering statutory bodies, associations and tertiary institutions alike are promoting it and there is a vast amount of research and literature available on the topic.

The cross-tabulation of demographic details shows no specific association arising with the question, as per Table 4.20.

5.2.5.2 Perceived Level of Engineering Leadership Knowledge in SA at Present

With reference to Figure 4.12, when testing the perceived current level of ‘knowledge’ of Engineering Leadership possessed by graduate engineers of local universities a majority (59%) of respondents rated them to possess ‘little knowledge of Engineering Leadership’. Only 5% of respondents rated ‘fair (amount of) knowledge’ and a smaller 1% rated ‘highly knowledgeable’. The negative response is concerning in light of the experienced industry perspective from the sample, indicating a gap within the education and training system.

The cross-tabulation of demographic details with the question show significant associations relating to age and experience of respondents, as per Table 4.20. A relatively large percentage (31.3%) of respondents with 'greater than 20 years of engineering experience' answered 'little knowledge', indicating a lack of confidence in graduate engineers from senior engineers.

5.2.5.3 Perceived Level of Engineering Leadership Competence in SA at Present

With reference to Figure 4.13, when further testing the perceived current level of 'competence' of Engineering Leadership possessed by graduate engineers of local universities, a majority (54%) of respondents rated them to possess 'little competence in Engineering Leadership'. Only 4% of respondents rated 'fair (amount of) competence' and 0% rated 'high competence'. The negative response is concerning as it also indicates a gap in the education and training system, as per the previously mentioned point in 5.2.5.2.

The cross-tabulation of demographic details with the question show significant association related to age, as per Table 4.20. A majority (53.7%) of respondents answered 'little competence' and, of this 53.7%, most (20.6%) belonged to the senior age group of 40 to 60 years old.

5.2.5.4 Perceived Engineering Leadership Competency Shortfalls in SA at Present

Respondents ranked the specific Engineering Leadership competency shortfalls in current graduate engineers as per Figure 4.14. Perceived as reasonable to fair shortfall was 'client/customer relation skills', 'ability to assess risk', 'industry/organisational knowledge', 'sense of urgency and will to deliver on time', 'written and oral communication skills', 'decision making skills', 'planning skills' and 'personal initiative'.

From the factor analysis carried out as per Table 4.6, the Engineering Leadership shortfalls tested were statistically divided into three sub-themes/components. The first sub-theme comprised ‘ sense of urgency and will to deliver on time’, ‘resourcefulness and flexibility’, ‘trust and loyalty in a team setting’, ‘ability to relate to others’, ‘quality orientated’, ‘creativity and innovation’, and ‘planning skills’. The group was subjectively seen as shortfalls relating to “professionalism and dynamic leadership shortfalls”. The second sub-theme included ‘client/customer relations skills’, ‘personal initiative’, ‘industry/organisational knowledge’, ‘decision making skills’, ‘self-management’ and the ‘ability to assess risk’. This second group was subjectively viewed as “personal self-regulation leadership shortfalls”. The third sub-theme identified comprised ‘engineering knowledge’, ‘written and oral communication skills’, ‘problem solving skills’ and ‘general knowledge’. This last group was subjectively viewed as “functional shortfalls in leaders”.

The section analysis carried out as per Table 4.13 illustrated that response trends varied when testing to what extent leadership competency shortfalls need to be addressed in undergraduates. Some items scored high perceived shortfalls (> 3=reasonable shortfall) with a significant difference ($p<0.05$) between those who scored above to those who scored below, from the null hypothesis of there being no difference. These include ‘engineering knowledge’, ‘personal initiative’, ‘decision making skills’, ‘self-management’, ‘problem solving skills’, ‘resourcefulness and flexibility’, ‘trust and loyalty in a team setting’, ‘ability to relate to others’, ‘general knowledge’, ‘quality orientated’, ‘creativity and innovation’, and lastly, ‘planning skills’. In these cases, more respondents scored higher levels of shortfalls and therefore were consistent. The remaining items that were tested scored high values in the binomial test, showing some agreement with the null hypothesis that there are a similar number of respondents scoring above as there were below. These items are less conclusive perceived shortfalls in comparison to the previous mentioned and included ‘written and oral communication skills’, ‘client/customer relations skills’, ‘industry/organisational knowledge’, ‘ability to assess risk’, and lastly, a ‘sense of urgency and will to deliver on time’.

Cross-tabulation of the demographics with the specific Engineering Leadership competency shortfalls indicated significant relationships between the registration status of respondents, the engineering discipline of respondents, the sector of work and/or the respondents engineering experience. Other relationships relating to the biographical details were also identified as per Table 4.21.

A review of the results from the correlations analysis carried out, as tabulated in Table 4.29(a) and Table 4.29(b), illustrates that all the items tested within the group have a significant level of correlation to each other. This was based on the manner in which items were scored. All relationships were calculated to be directly proportional (positive).

5.2.6 Section 4: Preferred Framework for any Future ELE in SA

5.2.6.1 Consensus Regarding the Incorporation of any ELE

With reference to Figure 4.15, when testing the consensus as to whether respondents want ELE into be included within South African tertiary education institutions a majority (91%) of respondents answered 'yes' to its inclusion. This result reaffirmed the view that serious future consideration needs to be given to ELE as per the industry's own desire.

The cross-tabulation of demographic details with the question indicated the only significant association related to gender, as per Table 4.20. There were no specific associations relating to the work experience variables to mention.

5.2.6.2 Consensus Regarding the Level/Extent of any ELE Implementation

With reference to Figure 4.16, when testing the consensus regarding the preferred extent/level of any ELE implementation within South African tertiary education institutions, a marginal (52%) of respondents preferred a non-explicit approach where Engineering Leadership is incorporated into other programmes. Since the result is marginal, further specific investigations would need to be carried out in future, or ECSA and universities may subjectively choose for themselves.

The cross-tabulation of demographic details with the question indicated the only significant association related to the employment sector of respondents, as per

Table 4.22. A majority (62.5%) of public sector engineers indicated they preferred explicit programmes or methods of implementation. The majority (56.9%) of private sector respondents in the sample indicated they prefer a non-explicit approach to ELE programmes.

5.2.6.3 Preferred Focus of the Aims/Goals to ELE Programmes

Respondents scored specific aims/goals which may be used for any newly developed ELE programmes implemented locally as per Figure 4.17. Of high preference was improving ‘ethical leadership’, ‘desire for demonstrating excellence’, ‘project management skills’ and the ‘ability to engage others’.

From the factor analysis carried out as per Table 4.7, the aims/goals tested were statistically divided into three sub-themes/components. The first sub-theme comprised improving ‘interpersonal skills’, ‘ethical leadership’, ‘visionary leadership’ and ‘industry leadership’, more so, it comprised developing ‘the ability to obtain team effectiveness’, ‘the ability to engage others’ and lastly ‘personal awareness and growth’. The group was subjectively viewed as programme aims/goals relating to ‘traditional leadership skills’. The second sub-theme included the development of ‘leadership skills’, ‘managerial (administrative) skills’, ‘entrepreneurial skills’, and furthermore it comprised the improvement of ‘business concepts’, ‘ability to solve business challenges’ and lastly ‘project management skills’. This second group was subjectively viewed as programme aims/goals targeted at ‘corporate/business leadership skills’. The third sub-theme identified comprised improving ‘skills in current technology’, as well as developing ‘desire for a positive impact on world challenges’ and a ‘desire for demonstrating excellence’. This last group was subjectively viewed as ‘progressive leadership skills’.

The section analysis carried out as per Table 4.14 illustrated that all responses tested from the scoring of preferred aims/goals for programmes were of high importance (> 3=reasonable importance) with a significant difference ($p<0.05$) between those who scored above to those who scored below.

Cross-tabulation of the demographics with the specific preferred programme aims/goals indicated a significant relationship with members' professional registration status, employment sector and years of experience within the industry. The first significant relationship identified was between members' professional registration status and experience within the industry with items including the 'improved understanding of business concepts', 'development of entrepreneurial skills' and the development of a 'desire for a positive impact on world challenges'. In this respect a majority of registered professionals were found to score between 'reasonable' and 'fair' attention required. Candidate engineers scored the mentioned items higher than registered professionals. Over 90% of engineers with 11 years or more of experience rated the 'development of entrepreneurial skills' as requiring 'reasonable' to 'considerable' attention. Approximately 60% of junior engineers with 1 to 5 years of experience within the industry rated the aim to 'develop a desire for a positive impact on world challenges' as requiring 'considerable attention'. The next significant relationship identified was between the respondent's employment sector and the 'development of managerial (administrative) skills'. Both public and private sector respondents rated the item as requiring much attention with approximately 90% of both sectors responding 'reasonable' to 'considerable' attention required. Other relationships relating to the biographical details were also identified as per Table 4.23.

A review of the results from the correlations analysis carried out, as tabulated in Table 4.30(a) and Table 4.30(b), illustrates that all the items tested within the group have a significant level of correlation to each other. This is based on the manner in which items were scored. All relationships were calculated to be directly proportional (positive).

5.2.6.4 Preferred Focus of the Themes within ELE Programmes

Respondents scored specific themes which may be used within any newly developed ELE programmes implemented locally as per Figure 4.18. Of high preference was training and development in 'ethics in engineering', 'communication skills', 'conflict management knowledge and skills' and 'project management knowledge and skills'.

From the factor analysis carried out as per Table 4.8 all the themes tested fell within a single theme/component. This indicated the results were purely a statistical measure of the ELE themes directly with no unobserved component/sub-theme.

The section analysis carried out as per Table 4.15 illustrated that respondents had split views with regard to two items of the preferred ELE themes, namely, ‘development of public relations knowledge and skills’ and ‘development of public policy knowledge and skills’. All other items tested were of high importance (>3=reasonable importance) with a significant difference ($p<0.05$) between those who scored above to those who scored below.

Cross-tabulation of the demographics with the specific preferred programme aims/goals indicated a significant relationship with members’ professional registration status, engineering discipline, employment sector and years of experience within the industry. The first significant relationship identified was between members’ professional registration status and experience within the industry with items including the ‘development of self-awareness and emotional intelligence knowledge and skills’, ‘development of innovation knowledge and skills’, ‘development of public policy knowledge and skills’ and the ‘training in finance, marketing and investment’. In regard to both registration and experience level, the majority of candidate engineers were found to score the mentioned items higher than registered professionals. The next significant relationship identified was between the respondent’s engineering discipline and the ‘development of negotiation knowledge and skills’. All disciplines predominantly scored the item as requiring ‘fair attention’. Lastly, the majority (93%) of private sector engineers scored the ‘development of career management knowledge and skills’ as requiring ‘reasonable’ to ‘considerable’ attention, marginally more than the public sector engineers (88%). Other relationships relating to the biographical details were also identified as per Table 4.24.

A review of the results from the correlations analysis carried out, as tabulated in Table 4.31(a) and Table 4.31(b), illustrates that all the items tested within the group have a significant level of correlation to each other. This is based on the manner in which items were scored. All relationships were calculated to be directly proportional (positive).

5.2.6.5 Preferred Focus for Methods/Approaches to ELE Programmes

Respondents scored specific methods/approaches which may be used in any newly developed ELE programmes implemented locally as per Figure 4.19. Of high preference was improving ‘peer/ faculty/ industry mentoring programmes’, ‘industry vacation work experience’, ‘personal leadership development plan(s) with mentor’ and ‘coordinated networking opportunities with leaders’.

From the factor analysis carried out as per Table 4.9 the methods/approaches tested were statistically divided into two sub-themes/components. The first sub-theme comprised improving ‘leadership coursework/modules’, ‘leadership workshops/seminars’, ‘team learning/scale projects’, ‘leadership reflection journals/ personal portfolios’, ‘personal leadership development plan(s) with mentor’, ‘coordinated networking opportunities with leaders’ and lastly, ‘on-campus/community leadership opportunities’. The group was subjectively viewed as programme methods/approaches relating to ‘alternate implementation methods’. The second sub-theme included ‘industry vacation work experience’ and ‘peer/ faculty/ industry mentoring programmes’. This second group was subjectively viewed as the ‘conventional implementation method’.

The section analysis carried out as per Table 4.16 illustrated that respondents had split views with regard to three items of the preferred ELE methods/approaches, namely, ‘leadership coursework/modules’, ‘leadership reflection journals/personal portfolios’ and ‘on campus/community leadership opportunities’. All other items tested were of high importance (>3=reasonable importance) with a significant difference ($p<0.05$) between those who scored above to those who scored below.

Cross-tabulation of the demographics with the specific preferred programme methods/approaches indicated a significant relationship with members’ professional registration status, engineering discipline, employment sector and years of experience within the industry. The first significant relationship identified was between members' professional registration status and items including 'leadership workshops/seminars', 'peer/faculty/ industry mentoring programmes', 'personal leadership development plan(s) with mentor', 'coordinated networking opportunities with leaders' and 'on campus/community leadership opportunities'. In this respect a majority (>90%) of registered professionals were found to score between 'reasonable' and 'considerable' attention required. Candidate engineers scored the mentioned items marginally lower than registered professionals. The next significant relationship existed between the respondent's specific engineering discipline and the 'leadership reflection journals/personal portfolios' approach. A majority (>90%) of electrical, electronic and computer engineers all scored the item as requiring 'fair' to 'considerable' attention while other disciplines scored the approach lower. It is important to note that the mentioned disciplines are often concurrently schooled and registered and thus may present similar thinking on the aspect. The next significant relationship identified was between the respondent's employment sector and the 'industry vacation work experience' approach, with 70% of private sector respondents scoring 'fair' to 'considerable' attention required. This was marginally more than public sector respondents (64%). The last relationship found was the respondent's years of engineering experience related to 'peer/faculty/industry mentoring programmes' and 'on campus/community leadership opportunities'. Here 90% of engineers with experience between 1 and 5 years scored the items as requiring 'fair' to 'considerable' attention while more experienced engineers were less preferred. Other relationships relating to the biographical details were also identified as per Table 4.25.

A review of the results from the correlations analysis carried out, as tabulated in Table 4.32(a) and Table 4.32(b), illustrates that all the items tested within the group have a significant level of correlation to each other. This is based on the manner in which items were scored. All relationships were calculated to be directly proportional (positive).

5.3 Conclusion

This chapter scrutinised the results and analysis of the survey. As such, a number of important deductions were made and trends identified. The results were found to be representative of the target population and to be reliable. The response base was found to consist of predominantly well-experienced, registered professional engineers and thus affirmed an experienced perspective of industry needs. Specific themes were identified as recurring and a significant desire for ELE implementation locally was confirmed. The following chapter draws more specific conclusions with regards to the research questions and provides recommendations to stakeholders and for future work.

CHAPTER SIX

Conclusions and Recommendations

6.1 Introduction

Engineering Leadership Education is becoming more main-stream within leading international engineering schools. The aim is to produce more globally competitive engineers who are leaders in society rather than technical workhorses that operate in isolation. SA has not yet commenced on this critical path of formally implementing leadership development for candidate engineers at undergraduate level. Currently ECSA narrowly calls for ‘leadership competency’ as a registration requirement of professional engineers. Against this backdrop the study sought to determine the consensus regarding the present leadership competency of local graduate engineers, to identify shortfalls (or gaps) in leadership, and lastly, to recommend a preferred framework for any future ELE programmes in SA. In this chapter the findings related to the research objectives and questions are summarised and overall conclusions are drawn. The limitations of the study are also explored and recommendations to ECSA, local tertiary institutions and other stakeholders are provided.

6.2 Answering the Research Questions

The purpose of the study was to investigate an industry-preferred framework to ELE for any future implementation within South African tertiary institutions, due to the current absence of formal leadership development in local graduate engineers. The key findings are discussed below in order to answer the research questions that were formulated to guide the study using information gathered through the literature review and from the actual results of the research survey carried out.

6.2.1 Research Question 1: What is meant by ‘leadership’ competency as a requirement for professional registration of engineers, by ECSA?

A fundamental question in the study was to identify what is meant by ‘leadership’ competency as a registration requirement of ECSA. This research question was answered through the review of specific literature to investigate, firstly, what ‘leadership’ is within an engineering context and, secondly, where leadership development and assessment comes into the ECSA registration process. The results derived from testing the various leadership principles, responsibilities and qualities was also taken as contributing to the specific important components of leadership, as per the local industry.

Based on the descriptions provided by various sources cited in the literature review (Chapter 2), Engineering Leadership refers to the capabilities required of professional engineers to provide vision for the future of society and to guide public policy in this regard. It is more fundamentally seen as the engineer’s ability to undertake the leadership role in ensuring the health, safety and welfare of all stakeholders.

The specific leadership capabilities that were tested and derived to be very important to the local engineering industry include engineering competence, high ethical standards, commitment, good communication skills, taking responsibility and, lastly, engaging others in a common vision. These qualities are in line with the NSPE’s (2010: 2) definition of Engineering Leadership as capabilities to “help create and communicate a vision for the future and the ability to help shape public policy”, which closely correlates to these competencies.

The literature also showed that ECSA calls for candidate engineers to provide evidence of their achievement of specific outcomes from postgraduate training for professional registration. The outcome Group B involving ‘Managing Engineering Activities’ which comprises Outcomes 4 and 5 narrowly calls for the demonstration of leadership. Outcome 4 calls for the demonstration of leadership in ‘controlling’ a team. Outcome 5 calls for the demonstration of communication with regards to various business and engineering fields and self-management. Further the literature indicates that ‘leadership competency’ is specifically positioned as a required ‘professional competency’, a subset of ‘enabling competencies’ required to achieve engineering outcomes. Leadership competency is expected to be developed post-graduation by taking on more ‘management duties’ and by attending optional courses.

6.2.2 Research question 2: What dimensions of leadership competency are delivered through international best practices of ELE?

In carrying out the literature review regarding leadership theory (specifically the Skills Model), leadership competency development and ELE, it was recognised that Engineering Leadership may be taught and learned, as is already done internationally at the undergraduate level. The study found, in this respect, that the local engineering industry overwhelmingly prefers that leadership development be introduced formally at the undergraduate level through ELE.

The review of international ELE programmes and other literature revealed the various dimensions of ELE for consideration in the development of any new programmes locally. Initially, institutions must decide on their preferred approach to ELE implementation, namely, explicit or non-explicit implementation. Various methods of leadership development ranging from coursework to coordinated networking opportunities require consideration. The goals, aims and themes of ELE programmes were also found to be diverse, with previous studies indicating little standardisation of the curriculums between institutions. Importantly, when testing preferences in this regard locally there is consensus as to where attention needs to be placed.

When looking at the leadership competency (skills and attributes) conveyed through ELE, specific Engineering Leadership responsibilities, principles and qualities/attributes are outlined by international engineering associations and educational institutions, to enhance an engineer’s personal knowledge and performance. This research tested the many competencies of leadership development outlined as international best practice, and ranked them in terms of importance to the local engineering industry. The results of this are conveyed in Chapters 4 and 5 where the specific competencies are detailed.

Lastly, specific themes/dimensions which comprised international best practice of ELE were ranked by local engineering respondents of the study. Ethics in engineering, communication skills, conflict management skills, project management skills, effective teamwork skills and business fundamental skills were all ranked highly as focus areas for local ELE programmes.

6.2.3 Research question 3: What is the perceived current level of leadership capabilities (or gaps) in present graduate engineers from South African tertiary institutions, by members of ECSA?

An important part of the research was to establish what the current perception of leadership competency is in local graduate engineers and which aspects require improvement. The research question was answered by firstly testing how the ECSA membership rated the leadership competency of current graduates and subsequently which of the listed shortfalls required more attention through ELE.

The level of leadership knowledge and competence were both tested to determine the ECSA membership's perception of competency in graduate engineers. The industry perception was found to be overwhelmingly negative in this respect with a majority of the experienced response base indicating that little knowledge of Engineering Leadership was possessed by local graduates. This translated into the further rating of little Engineering Leadership competence possessed. It is evident that there is a leadership development gap which needs to be addressed such that confidence may improve in this area by local industry.

Common Engineering Leadership shortfalls were investigated through the review of literature on the topic and were subsequently tested. In support of the notion that engineering schools tend to focus on technical skills and neglect soft skills, the results indicated that graduate engineers tend to be much stronger in 'engineering knowledge' than 'client/customer relation skills'. By giving more attention to the specific soft skills conveyed as reasonable to fair shortfalls of leadership it may be possible to produce more well-rounded professional engineers.

6.2.4 Research question 4: What is the consensus among the ECSA membership about any possible implementation of ELE, within South African tertiary institutions?

It was important to determine the level of desire that the local engineering industry have for implementing any ELE in SA. The support for or against ELE from arguably the most significant stakeholder of local engineering education could largely influence ECSA and some local engineering schools' position regarding the topic in the future. The research question was answered by primarily testing whether or not ECSA members desire ELE to be incorporated into South African tertiary education. Subsequently, the desired level of implementation was tested to determine whether leadership development was preferred to be the primary objective, with new specific programmes being developed, or if it should be incorporated into other programmes which have their own primary objectives.

The overwhelming desire (91%) in favour of the incorporation of ELE affirms that on reflection of the current leadership development circumstances there is a recognised need to improve on current efforts via the educational system and process. It was however evident that the ECSA membership is split almost evenly with regards to the level of implementation any new ELE should take on. Further investigation should take place to establish any consensus or universities and ECSA may subjectively decide on their preferred approach. It was noted that public sector engineers preferred an explicit approach while private sector engineers preferred a non-explicit approach.

6.2.5 Research question 5: What is ECSA members' preferred framework to ELE based on international best practices, which could be implemented within South African tertiary institutions?

The last objective of the study was to formulate a baseline conceptual framework of ELE which is based on international best practices and the preferences of ECSA members. This was so that ECSA and engineering schools could possibly use the study to develop future programmes. The research question associated with this objective was answered by firstly identifying international best practices in terms of programme approach, aims, goals and themes, as well as specific leadership development aspects such as principals, responsibilities, qualities and attributes. Secondly, the industry preferences associated with the components of the framework were tested. The resulting framework follows as per Figure 6.1.

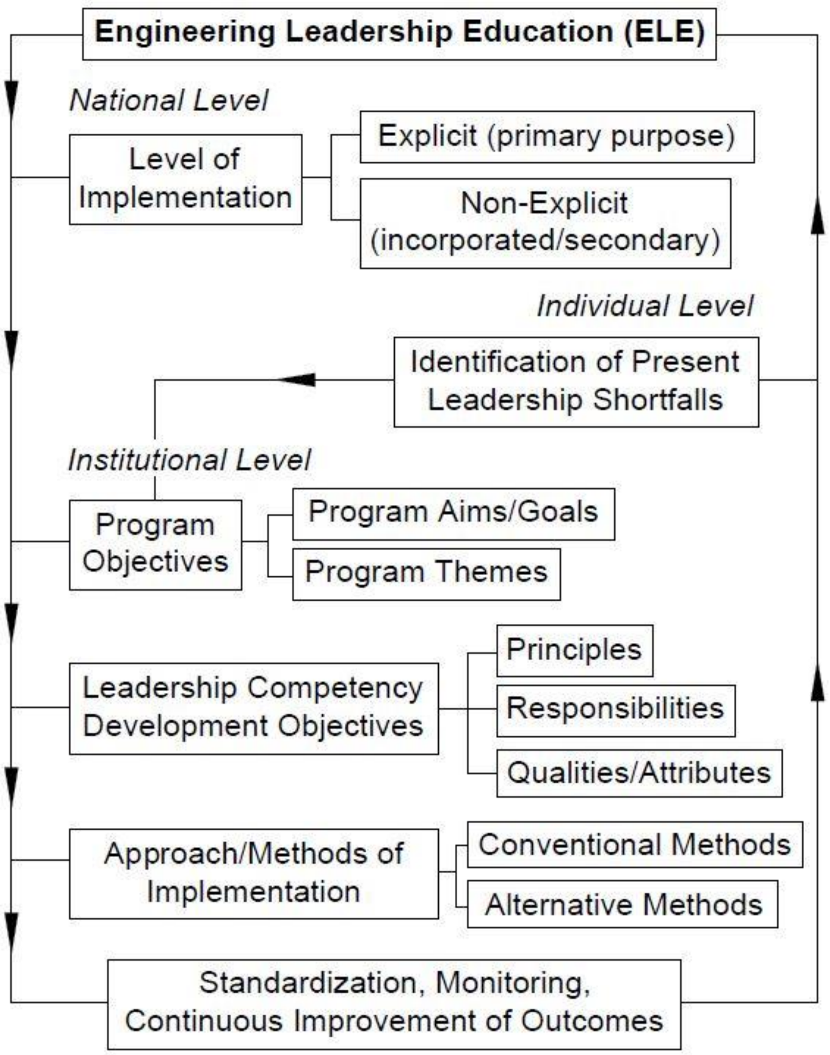


Figure 6.1: Summarised illustration of the conceptual framework to ELE

Source: Constructed by author

6.3 Limitations of the Study

Various limitations to the study arose at different stages of the research. As mentioned, the lack of awareness of ELE locally translated to a scarcity of local literature and a reliance on international work on the topic. This necessitated that the respondents be guided systematically through the survey such that there was sufficient understanding. Due to financial and time constraints a decision to use a comprehensive survey was taken instead of an interview process, which would have been too vast and time-consuming in nature due to the size and diversity of the target population. The survey method carried out may possibly limit the findings to the particular time period of the study as the nature of survey research tends to provide a view of a snapshot in time. Another notable limitation to the research is that it was confined to focusing on an industry perspective and did not directly engage other stakeholder groups including ECSA's education board, the education department, tertiary education institutions, employers, clients and students. Lastly, a major difficulty experienced was the nationwide distribution of the survey through the individual engineering associations. It took much time to liaise with and obtain approval for the survey's distribution and in some cases these discussions were not fruitful.

6.4 Recommendations of the Study

Engineering Leadership development efforts in SA have been found to be significantly lagging behind other international engineering schools. ECSA's current 'leadership competency' professional registration requirements were found to be too narrow and vague in comparison to other international statutory bodies. The registration requirements in terms of leadership competency must primarily be reviewed and improved in line with international best practices. More awareness regarding ELE needs to take place locally as a large percentage of the industry is unfamiliar with the topic.

The opportunity cost of doing nothing to change the situation is that international engineering graduates of the future may offer better performance or be perceived in such a manner by employers and society, over local engineering graduates. This study has confirmed that there is a great desire from the local engineering industry and more specifically, ECSA members, for ELE to be incorporated into the South African tertiary education system. Further, when looking at how poorly local experienced industry professionals rate current local engineering graduates' leadership knowledge and competency, the recommendation follows that ELE implementation must be prioritised.

ECSA and the Department of Higher Education and Training need to further investigate and decide on the approach the country should take (explicit, non-explicit or none) to incorporate ELE, locally. This could also be left optional to engineering schools, however they need to consider future professional registration requirements with ECSA in such regard.

The results revealed that the local engineering industry prefers future ELE programmes to primarily adopt 'conventional implementation methods' such as mentoring programmes, work experience and development plans. It is however recommended that this must be accompanied with well-structured theoretical knowledge, delivered through specific Engineering Leadership coursework. Further, such an approach must keep sight of achieved outcomes for baseline standardisation and improvement.

A strong desire for the development of ethical leadership, professional accountability and project management skills was conveyed by industry. These preferences remain uncontested and are the recommended focus for any future programmes. All of the specific preferences regarding each component of the conceptual framework to ELE development and implementation should be considered, as outlined in previous chapters.

6.5 Recommendations for Future Studies

- Much work and research opportunity exists in the local context to develop and implement ELE within SA. Most fundamentally, a general awareness of the vastness and beneficial nature of effective leadership development needs to be raised.

- At a national level, work needs to be done to enhance the registration guidelines for engineering leadership competency. More clear guidelines as to its definition, development and assessment need to be specified by ECSA, in line with efforts made by other leading accreditation bodies. Also, the various tertiary education institutions need to examine how best to incorporate ELE into their curriculums.

- At an employment level, more research needs to be carried out to determine what the specific engineering industry and discipline needs are for leadership, and how to best develop them.

- At an individual level, work needs to be carried out to identify the challenges experienced by students in progressing through to professional registration, in terms of leadership development.

6.6 Conclusion

An engineering industry that offers visionary leadership, in addition to sound technical competence, is SA's best chance of moving forward to a healthier and safer society than the present one. An important understanding developed through the study is that this leadership can and should be developed at the grassroots level of engineering. This research was a baseline study into what needs to be achieved to bring ELE into a South African context. Further, the research highlights the preferences and role of ECSA and other important stakeholders, in this regard. The existing international work on the topic was received as a valuable mine of information from which SA can engineer its own leadership development programmes, which this research project has effectively commenced.

> *"What is leadership? What makes a leader a good one? Are leaders born or made? And can one country be blessed with more [good] leaders than another country?" (Planting, 2018: 1).*

> *"In the past, intellectually talented engineers with strong technical skills were sufficient for the needs of society. In the 21st century engineers are now working in the corporate world, often disconnected from the hands-on aspect of engineering. Professional skills such as leadership have become critical for graduating engineers entering the workforce." (Paul & Falls, 2015a: 1).*

> *"Many also argue that an engineer is hired for his or her technical skills, fired for poor people skills, and promoted for leadership and management skills." (ASCE, 2008: 145).*

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APPENDICES

Appendix 1: Gatekeeper's Consent

ENGINEERING COUNCIL OF SOUTH AFRICA

ECSA

Engineering Council of South Africa (ECSA)
1st Floor, Waterview Corner Building
2 Ernest Oppenheimer Avenue
Bruma Lake Office Park, Bruma
Johannesburg
2198

16 September 2018

Kobashen Moodley
44 Ishwari Road
Raisethorpe
Pietermaritzburg
3201

Your Reference: K. Moodley (UKZN – 207500632 / ECSA Reg. Number – 201350162)
Our Reference: ECSA – Gatekeepers Authority

RE: PERMISSION TO CONDUCT RESEARCH

To Whom It May Concern:

This letter serves to support Kobashen Moodley (207500632) of the University of KwaZulu-Natal to conduct data collection from members of the Engineering Council of South Africa (ECSA), for his research titled *"Industry preferences of future Engineering Leadership Education in South African tertiary institutions"*. The participation is voluntary and members can use their own discretion. The council name may be used in the dissertation for academic research purposes only.

The study should be conducted within the ambit of good research and ethics as laid down by the University and include confidentiality and anonymity where necessary.

We wish you well in your research.

Kind regards,

[redacted]

Mr Christopher Tsatsawane
Executive: Strategic Services

www.ecsa.co.za

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Tel: +27 11 607 9500 · Fax: +27 11 622 9295 · E-mail: engineer@ecsa.co.za

Appendix 2: University Research Ethics Committee Clearance

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

31 August 2018

Mr Kobashen Moodley (207500632)
Graduate School of Business & Leadership
Westville Campus

Dear Mr Moodley,

Protocol reference number: HSS/1272/018M
Project title: Industry preferences of future Engineering Leadership Education in South African tertiary institutions

Approval Notification – Expedited Application

In response to your application received 23 August 2018, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol has been granted **FULL APPROVAL**.

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment /modification prior to its implementation. In case you have further queries, please quote the above reference number.

PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

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

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

Yours faithfully

[redacted]

Dr Shamila Naidoo (Deputy Chair)

/ms

Cc Supervisor: Professor Muhammed Hoque
Cc Academic Leader Research: Dr Rosemary Sibanda
Cc School Administrator: Ms Zarina Bullyraj

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

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Founding Campuses: Edgewood · Howard College · Medical School · Pietermaritzburg · Westville

Appendix 3: Respondents' Informed Consent

UNIVERSITY OF KWAZULU-NATAL
GRADUATE SCHOOL OF BUSINESS AND LEADERSHIP

MBA Research Project
Researcher: Kobashen Moodley ([redacted]/ kobashen@gmail.com)
Supervisor: Prof. C.N. Gerwel Proches (0312608318)
Research Office: Ms P Ximba (0312603587)

Dear Respected Member of ECSA,

I, Kobashen Moodley am an MBA student, at the Graduate School of Business and Leadership, of the University of KwaZulu Natal. I would like to invite you to participate in a research project titled *Industry Preferences of Future Engineering Leadership Education (ELE) in South African Tertiary Education Institutions*. The aim of this study is to determine a preferred approach and focus to ELE that South African engineering schools could implement, based on international best practices.

Through your participation, I hope to understand what are the preferred goals, themes and approaches to ELE, by the local engineering industry. The results of the study are intended to contribute to the local body of knowledge on the topic and benefit future engineering graduates, engineering schools, employers and ECSA's accreditation and registration guidelines.

Your participation in this project is voluntary. You may refuse to participate or withdraw from the project at any time with no negative consequence. There will be no monetary gain from participating in this survey. Confidentiality and anonymity of records identifying you as a participant will be maintained by the Graduate School of Business and Leadership, UKZN.

If you have any questions or concerns about completing the survey or about participating in this study, you may contact me or my supervisor on the numbers listed above. Alternatively, you may contact the university's research office.

The survey should take you about 10 minutes to complete and remains open until the 30th September 2019. I hope you will take the time to complete it as the study strives to obtain approximately 380 valid responses.

CONSENT AND SURVEY LINK:

I, hereby confirm that I understand the contents of this document and the nature of the research project, and I consent to participating in the research project. I understand that I am at liberty to withdraw from the project at any time, should I so desire.

Web link to proceed with the academic survey on Google Forms:
https://forms.gle/h1CP5E6c8eNpMxJT6

Appendix 4: Research Questionnaire

Research Survey: Industry preferences of future Engineering Leadership Education within South African tertiary education institutions

Thank you for choosing to participate.
Please continue to complete the survey.
The survey comprises of this initial demographics section followed by 3 sections of multiple choice/selection questions. There are 12 questions in total, excluding Section 1. There are no incorrect answers for Section 2, 3 & 4.

*Required

Section 1 of 4: Demographics

1. **1.1 What is your present age group?** *
Mark only one oval.
- 16 to 24
- 25 to 39
- 40 to 60
- 60 plus

2. **1.2 What is your associated gender?** *
Mark only one oval.
- Female
- Male
- Other

3. **1.3 What is your associated race?** *
Mark only one oval.
- African
- White
- Coloured
- Indian
- Other

4. **1.4 Are you a member of the Engineering Council of South Africa (ECSA)?** *
Mark only one oval.
- Yes
- No

5. **1.5 Are you a Professionally registered member of ECSA?** *

Mark only one oval.

- No, I am not a registered member of ECSA at all
- No, but I am currently a registered candidate Engineer/Technologist/Technician, etc.
- Yes, I am a registered Professional Engineer/Technologist/Technician, etc.

6. **1.6 Which engineering discipline do you work within?** *

Mark only one oval.

- Aeronautical
- Agricultural
- Civil
- Chemical
- Computer
- Electrical
- Electronic
- Industrial
- Mechanical
- Other, not mentioned here

7. **1.7 Are you employed within the public or private sector?** *

Mark only one oval.

- Public Sector - Municipal/Government Departments/ State Owned Enterprises, etc.
- Private Sector - Consulting/ Mining/ Production or Service Industry, etc.
- Other, not mentioned here

8. **1.8 Approximately how many years of experience do you have within the engineering profession?** *

Mark only one oval.

- None
- 1 to 5 years
- 6 to 10 years
- 11 to 20 years
- Greater than 20 years

Section 2 of 4: Overview of Engineering Leadership Competency

Please complete all sections and submit before closing the survey.

9. **2.1 Please indicate how important & valued the following Engineering Leadership Responsibilities are in your specific engineering work** *

Rating: 1 = Not important, 2 = Little Importance, 3 = Reasonable importance, 4 = Important, 5 = Very Important (Rate each in relation to others for better perspective)

Mark only one oval per row.

	1	2	3	4	5
Being able to develop and engage others in a common vision	◯	◯	◯	◯	◯
Clearly planning and organizing resources	◯	◯	◯	◯	◯
Developing and maintaining trust	◯	◯	◯	◯	◯
Sharing perspectives	◯	◯	◯	◯	◯
Inspiring creativity	◯	◯	◯	◯	◯
Heightening motivation	◯	◯	◯	◯	◯
Being sensitive to competing needs	◯	◯	◯	◯	◯
Upholding and leading good ethical behavior	◯	◯	◯	◯	◯

10. **2.2 Please indicate how important & valued the following Engineering Leadership Principles are in your specific engineering work** *

Rating: 1 = Not important, 2 = Little Importance, 3 = Reasonable importance, 4 = Important, 5 = Very Important (Rate each in relation to others for better perspective)

Mark only one oval per row.

	1	2	3	4	5
Being technically competent	◯	◯	◯	◯	◯
Knowing oneself (abilities) and seeking self improvement	◯	◯	◯	◯	◯
Making sound and timely decisions	◯	◯	◯	◯	◯
Setting the example	◯	◯	◯	◯	◯
Seeking responsibility and taking responsibility for one's actions	◯	◯	◯	◯	◯
Communicating with and developing subordinates both as individuals and as a team	◯	◯	◯	◯	◯
Ensuring that a project is understood, supervised and accomplished	◯	◯	◯	◯	◯

11. **2.3 Please indicate how important & valued the following Engineering Leadership Qualities/Attributes are in your engineering work** *

Rating: 1 = Not important, 2 = Little Importance, 3 = Reasonable importance, 4 = Important, 5 = Very Important (Rate each in relation to others for better perspective)
Mark only one oval per row.

	1	2	3	4	5
Vision	◯	◯	◯	◯	◯
Enthusiasm	◯	◯	◯	◯	◯
Industriousness	◯	◯	◯	◯	◯
Initiative	◯	◯	◯	◯	◯
Competence	◯	◯	◯	◯	◯
Commitment	◯	◯	◯	◯	◯
Selflessness	◯	◯	◯	◯	◯
High ethical standards	◯	◯	◯	◯	◯
Adaptability	◯	◯	◯	◯	◯
Communication skills	◯	◯	◯	◯	◯
Discipline	◯	◯	◯	◯	◯
Confidence	◯	◯	◯	◯	◯
Courage	◯	◯	◯	◯	◯
Curiosity	◯	◯	◯	◯	◯
Persistence	◯	◯	◯	◯	◯

Section 3 of 4: Perceived level of Engineering Leadership Competency in South Africa at present

Please complete all sections and submit before closing the survey.

Answer the following questions based on the scope of Engineering Leadership outlined in the previous section and on your own knowledge and experience.

12. **3.1 Did you know that Engineering Leadership can be developed (taught and learned) at undergraduate level?** *

Mark only one oval.

◯ Yes
◯ No

13. **3.2 How do you rate the current level of KNOWLEDGE possessed by most recently graduated engineers, from local universities, with regards to the topic of Engineering Leadership?** *

Mark only one oval.

◯ No knowledge of Engineering Leadership
◯ Little knowledge of Engineering Leadership
◯ Reasonable knowledge of Engineering Leadership
◯ Fair knowledge of Engineering Leadership
◯ Highly knowledgeable of Engineering Leadership

14. **3.3 How do you rate the current level of COMPETENCE possessed by most recently graduate engineers, from local universities, with regards to Engineering Leadership implementation at work? ***

Mark only one oval.

- No competence in Engineering Leadership
- Little competence in Engineering Leadership
- Reasonable competence in Engineering Leadership
- Fair competence in Engineering Leadership
- High competence in Engineering Leadership

15. **3.4 To what extent do you rate the following Leadership Competencies as Shortfalls (or Gaps) in South African graduate engineers which need to be addressed at undergraduate level? ***

Rating: 1 = No shortfall (Satisfactory competence), 2 = Minimal shortfall, 3 = Reasonable shortfall, 4 = Fair shortfall, 5 = Major shortfall (needs earlier development) - Rate each in relation to others for better perspective

Mark only one oval per row.

	1	2	3	4	5
Engineering knowledge					
Written and oral communication skills					
Client/customer relations skills					
Personal initiative					
Industry/organisational knowledge					
Decision making skills					
Self-management					
Problem solving skills					
Ability to assess risk					
Sense of urgency and will to deliver on time					
Resourcefulness and flexibility					
Trust and loyalty in a team setting					
Ability to relate to others					
General knowledge					
Quality orientated					
Creativity and Innovation					
Planning skills					

Section 4 of 4: Preferred framework for any future Engineering Leadership Education (ELE) in South Africa

Please note this last section (Section 4) is slightly longer than the previous sections. However it is simple and of great importance to the overall survey. Please complete all five (5) questions and submit before closing the survey.

Answer the following questions based on the scope of Engineering Leadership outlined in the previous sections and your own knowledge and experience.

16. **4.1 Do you believe that Engineering Leadership Education should be incorporated into South African tertiary education institutions? ***

Mark only one oval.

- Yes
- No

17. **4.2 Which approach to any newly implemented Engineering Leadership Education do you believe would be best suited to engineering undergraduate programs in South Africa?** *

Mark only one oval.

- ◯ Explicit programs - where Engineering Leadership development is the primary objective of an implemented program
- ◯ Non-explicit programs - where Engineering Leadership development is incorporated into other programs which have their own primary objectives

18. **4.3 Please indicate how much focus should be given to the following Aims/Goals of ELE programs, when developing such programs for South Africa** *

Rating: 1 = No attention, 2 = Little attention, 3 = Reasonable attention, 4 = Fair attention, 5 = Considerable attention (Rate each in relation to others for better perspective)

Mark only one oval per row.

	1	2	3	4	5
Development of leadership skills	◯	◯	◯	◯	◯
Development of managerial (administrative) skills	◯	◯	◯	◯	◯
Improved understanding of business concepts	◯	◯	◯	◯	◯
Development of entrepreneurial skills	◯	◯	◯	◯	◯
Improved skills in current technology	◯	◯	◯	◯	◯
Improved ability to solve business challenges	◯	◯	◯	◯	◯
Improved interpersonal skills	◯	◯	◯	◯	◯
Improve ethical leadership	◯	◯	◯	◯	◯
Improve visionary leadership	◯	◯	◯	◯	◯
Improve industry leadership	◯	◯	◯	◯	◯
Improve project management skills	◯	◯	◯	◯	◯
Develop desire for a positive impact on world challenges	◯	◯	◯	◯	◯
Develop ability to obtain team effectiveness	◯	◯	◯	◯	◯
Develop ability to engage others	◯	◯	◯	◯	◯
Develop personal awareness and growth	◯	◯	◯	◯	◯
Develop desire for demonstrating excellence	◯	◯	◯	◯	◯

19. **4.4 Please indicate how much focus should be given to the following Themes of ELE programs, when developing such programs for South Africa** *

Rating: 1 = No attention, 2 = Little attention, 3 = Reasonable attention, 4 = Fair attention, 5 = Considerable attention (Rate each in relation to others for better perspective)

Mark only one oval per row.

	1	2	3	4	5
Understanding of leadership theory and practice					
Understanding of business fundamentals					
Development of project management knowledge and skills					
Development of negotiation knowledge and skills					
Development of career management knowledge and skills					
Development of presentation knowledge and skills					
Development of teamwork knowledge and skills					
Development of self awareness and emotional intelligence knowledge and skills					
Development of conflict management knowledge and skills					
Training in how to effectively lead and motivate					
Training in ethics in engineering					
Development of public relations knowledge and skills					
Training in communication skills					
Training in managing interdisciplinary engineering teams					
Development of innovation knowledge and skills					
Development of public policy knowledge and skills					
Training in finance, marketing and investment					
Training in working effectively with others					

20. **4.5 Please indicate how much focus should be given to the following Methods/Approaches to Engineering Leadership development, when developing ELE programs for South Africa**
*

Rating: 1 = No attention, 2 = Little attention, 3 = Reasonable attention, 4 = Fair attention, 5 = Considerable attention (Rate each in relation to others for better perspective)
Mark only one oval per row.

	1	2	3	4	5
Leadership coursework/modules					
Leadership workshops/seminars					
Team learning/scale projects					
Industry vacation work experience					
Peer/ faculty/ industry mentoring programs					
Leadership reflection journals / personal portfolios					
Personal leadership development plan(s) with mentor					
Coordinated Networking opportunities with leaders					
On campus/Community leadership opportunities					

Appendix 5: Turnitin Results

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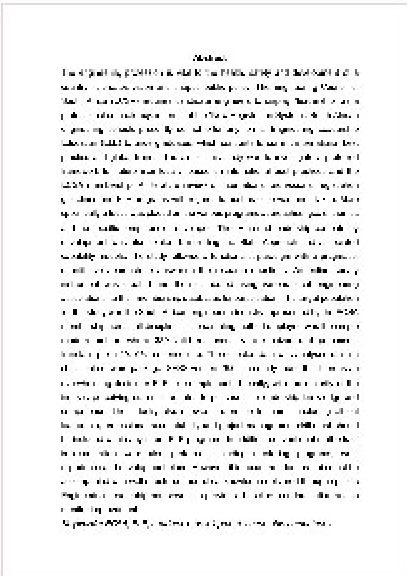

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