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Challenges facing projects due to a lack of resources

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ABBREVIATIONS

BA	Bachelor of Arts
BBBEE	Broad Based Black Economic Empowerment
ECSA	Engineering Council of South Africa
GDP	Gross Domestic Product
HIV	Human immunodeficiency virus
IT	Information Technology
MBA	Masters in Business Administration
NTC	National Trade Certificate
PHD	A Doctor of Philosophy
PM	Project Managers
PMBok	Project Management Body of Knowledge
PWC	PricewaterhouseCoopers
SMME	Small, Medium and Micro-sized Enterprises



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ABSTRACT

One of the major challenges facing many Engineering companies today is the lack of sufficient resources to staff all projects concurrently. The objective of this study is to understand the challenges on engineering projects due to the lack of resources. The aim is to assess the problem in South Africa and develop a suitable strategy and action, to manage the challenge of limited Engineering resources. This dissertation will be limited to researching the challenges facing Civil Engineering projects due to the lack engineering resources in South Africa.

All projects require human resources because they play an important role in any project. These resources may contribute to either a projects success or failure. Therefore having the correct people for the project is extremely important. Projects compete against each other for resources, and this result in Engineers assigned to several projects at the same time.

The most common and widely experienced challenge on a project is insufficient team skills. Organisations should consider outsourcing of work versus in-house; leadership's skills; human management and skills management, to ensure project success when it comes to skilled resources.

The main findings of this research study revealed that the highest impact on a projects success is to comply with the planned budget, time frame and performance criteria. This is followed by having competent project team members. Other factors for a projects success included having clearly defined goals, directions, roles and responsibilities. Further improvements from various organisations (viz. Government, Companies and Universities) are also required for a project to succeed.

CHAPTER 1: INTRODUCTION AND RESEARCH OBJECTIVES

1.1 Background to the Study

Due to globalization, one of the greatest challenges we face today is the delivery of basic services to meet an expanding population. Innovation in engineering is fundamental to address these challenges. However, we are failing to encourage the new generation that Engineering careers are exciting, well-paid and worthwhile.

One of the major issues facing many Engineering companies today is the lack of sufficient resources to staff all projects concurrently. As such, projects compete against each other for resources, and people are assigned to several projects at the same time. Engineers with special expertise of scarce skills may be in high demand due to constraints, thus causing bottlenecks.

In South Africa, a shortage of key skills is affecting business growth and this requires government intervention. In 2013, PricewaterhouseCoopers (PWC) [1] found in an international survey of business leaders that the mining, energy, engineering and construction companies experienced the most chronic shortage of skilled employees. Research carried out by Adzuna South Africa [2] in 2016; revealed that Science, Technology, Engineering and Mathematics are still the best skills to have to ensure a good job, stable career and better-than-average salary. The recruitment of Engineers was on the list of the top three of the ten most prolific job titles.

All engineering companies are organisations that perform Project Management and therefore face numerous challenges. These challenges will increase or decrease in severity of the situational analysis and this is dependent on the organization's set up. According to Mark [3], on one end is a 'functional organisation' that runs very few projects and is not ideally set up to deal with specific consistencies of project management. While on the other end is the projectized organisation, and this makes a living by doing projects. In the centre is the matrix organisation and it is a combination of both functional and projectized organisations. Organisations rely on projects to ensure the business needs. Projects rely on resources to ensure the project meets its goal. Therefore, projects rely on the effective employment of limited resources, whether these are people, equipment or facilities, anything required to complete a project activity or task and has a financial implication. Organisations experience challenges of ensuring that they make the most of these available limited resources.

1.2 Problem Statement

According to the Rambaran [4], many Engineering companies find it difficult to fill Engineering posts since 10 and 15 years of experience is required. While this may be the case, on the other side, many newly graduated Engineers are struggling to find employment. With Local Government and Municipalities in South Africa facing an unhealthy position, it is almost unbelievable that one finds few or in some instances no civil engineering professional in their employ. In 2010, the Engineering Council of South Africa (ECSA) stated [4] that “the international benchmark of an average population per engineer shows that South Africa lags behind other developing countries”. In South Africa, one engineer services 3 166 people of the population, compared to Brazil’s 227 and Malaysia’s 543 per engineer. The discrepancy in the benchmark points to one thing; South Africa is severely under-engineered with a dire shortage of competently qualified Engineers.

1.3 Objectives of the Study

In Project Management, resources are required to carry out the project tasks. Resources can be people, equipment, facilities, funding, or anything else capable of definition (usually other than labour) required for the completion of a project activity. In the case of this study, employees in the engineering profession are referred to as ‘Resources’. In order for a project to run efficiently and effectively, sufficient resources are required to complete tasks. The objective of the study is therefore to provide the reader with the necessary background to understand the challenges facing Engineering projects in South Africa with limited resources to carry out engineering related projects. The aim is to assess the situation in South Africa, develop a suitable strategy and implement goals to manage this challenge of limited engineering resources.

1.4 Scope of the Study

The scope of this study will be limited to researching the challenges facing Civil Engineering projects due to the lack or inadequate Engineering resources viz. Engineers, Technicians and Technologist.

The study is specifically directed at projects carried out by South African consultants within the Civil Engineering spectrum and restricted to one of South Africa’s largest consulting Civil Engineering Company. The focus is on the internal situation of an organisation.

1.5 Research Limitations

The sample has been restricted to a large consulting Civil Engineering company in South Africa because of the limited time to cover all the Engineering Consultants in South Africa. The results from this company will be taken as a representative of all the Consultants of a similar size and nature.

1.6 Organisation of the Dissertation

The chapters of this study are as follows:

1.6.1 Chapter 1: Introduction and Research Objectives

This chapter highlights the background, problem statement objectives and scope to the study.

1.6.2 Chapter 2: Literature Review

This chapter provides an overview of the literature review to this research problem.

1.6.3 Chapter 3: Research Methodology

This chapter discusses the research methodology and the data collection approach

1.6.4 Chapter 4: Analysis of data and Discussions of Findings

The data collected and the analysis of the results obtained from the questionnaire are tabulated in this chapter. These results will verify the research objectives derived in Chapter 1.

1.6.5 Chapter 5: Conclusion and Recommendations

This chapter summarizes the findings of the research with conclusions drawn and tentative recommendations made. Recommendations for further research work are also given.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

All projects require human resources, as people are the most important resource to a project, irrespective of the size and complexity of the project. Projects require specific expertise at a specific moment or phase of the project. Moreover, projects often require talent and resources. To ensure the success of a project, it is critical that the procurement and coordinating of these human resources, in conjunction with managing the time aspect of the project. According to the Project Management Body of Knowledge (PMBOK) [5], a project team consists of people with assigned roles and responsibilities for the completion of a project. The PMBOK further states that, "Participation of team members during planning adds their expertise to the process and strengthens their commitment to the project." One of the many reasons why projects fail is due to insufficient resources [6]. The '5 Whys technique' [7] is used to investigate the cause and effect to the problem statement, Why is there a lack of Resources? The basis of the literature review arises from questions relating to resources on projects and shown Figure 1.

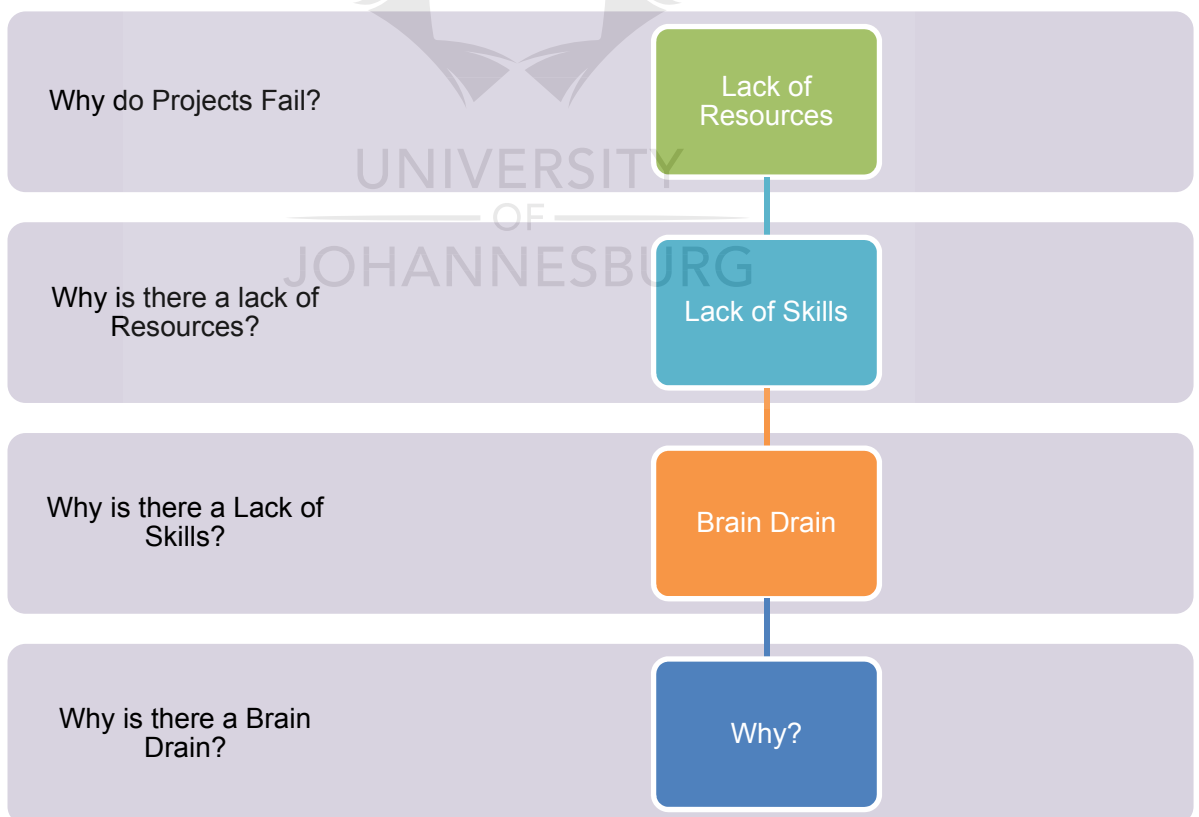


Figure 1: Problems regarding resources on projects

2.2 Project Failure challenges

Every project is different and therefore there are several reasons attributed to Engineering project failure. Every failed project will have its own set of issues and causes for failure. Sometimes, a single event can cause a project to fail. Often, a set of complex problems results in failure.

Various factors may cause projects to fail. Frese [6] identified that the top 10 factors found in “Failed” projects are:

- Incomplete requirements
- Lack of user involvement
- Lack of resources
- Unrealistic expectations
- Lack of executive support
- Changing requirements & specifications
- Lack of planning
- Didn't need it any longer
- Lack of IT management
- Technical illiteracy

As illustrated in Figure 2, a survey conducted during a project management course by Attarzadeh and Ow [8] on a project team of 50 undergraduate students indicated that lack of resources (11%) was the third highest cause of project failure based on the percentage of responses. The top 2 factors for project failure were incomplete requirements (13%) and lack of user involvement (12%).

Dubber and Pretorius [9] identified that changes in management, either resignation or a transfer has a negative effect on the performance of a project. The result of replacing the core foundation of the project can be poor management of the project management triple constraint (budget, scope and time), confusion and misunderstanding within the team and reduced team spirit.

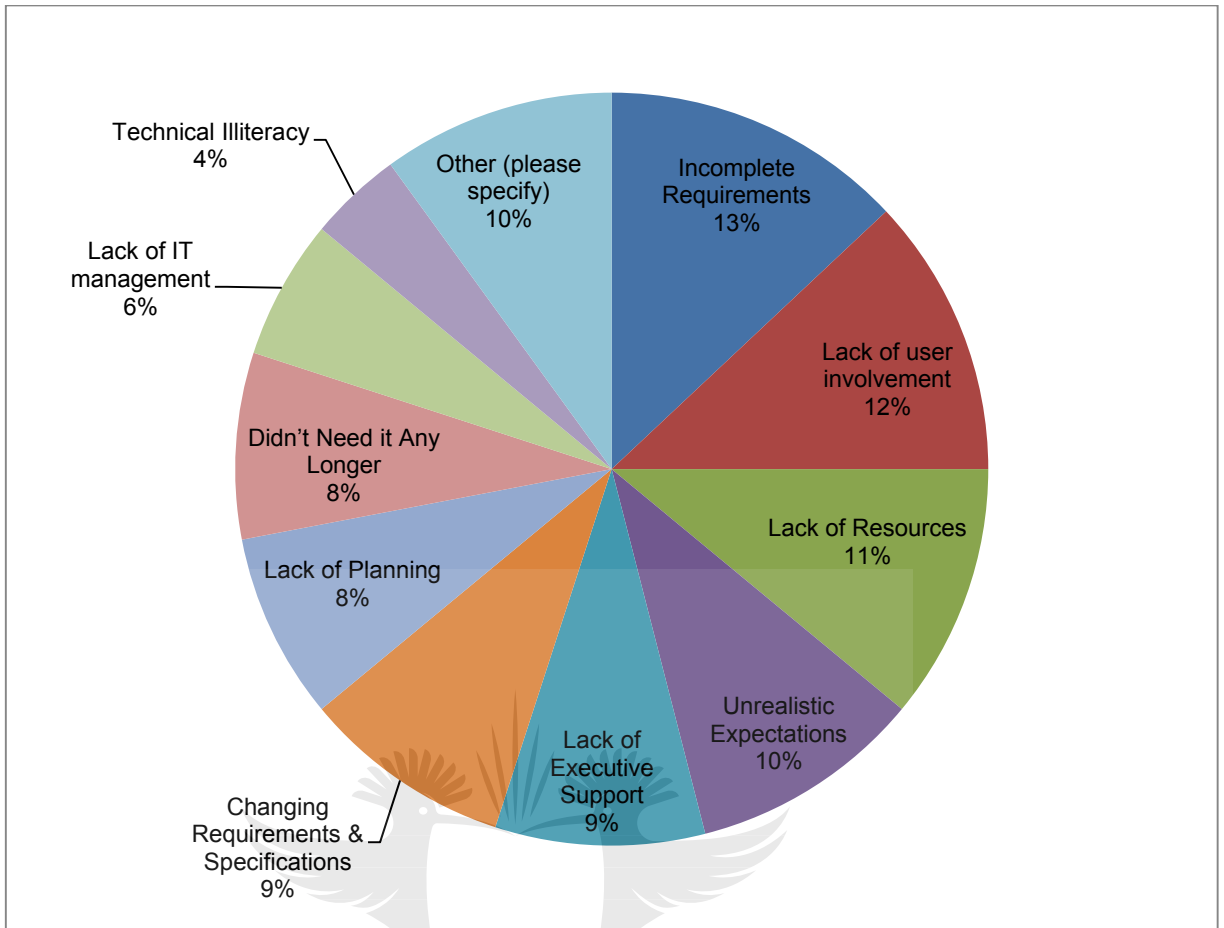


Figure 2: Percentage of Failed Project Factors (Attarzadeh and Ow [8])

Resources play an important role in any project. They may contribute to either a projects success or failure. There are various reasons [10] how resources may affect the project negatively.

- Change: Change in the scope may result in a lack of resources, as these resources may be required on other projects. Changes to the resources (needed on another project or resignation from the organisation) can affect the project.
- Scheduling: Human Resources downtime can result in failure or lack of requisite skills could result in increased project cost.
- Funding: results in failure due to inadequate funding for the correct resources.
- Resources: A project can fail due to the incorrect or insufficient resources used on the project.
- Incentives: Engineers/Resources feel that they are not motivated on successful completion of a task.

The understanding and interpretation of the triple constraint is crucial to the success of any projects [11]. The components of the triple constraint, scope, cost and time is interconnected. Failure to one competent affects the other two components as all three of the constraints works in tandem. It is evident that there are many causes for a project to fail. Some causes can be independent while others are dependent, e.g. a change in scope does not only affect the cost but also the schedule and resource allocation. In most cases, the common factors boils down to resources and the lack thereof. In this study, we will only focus on the challenges experienced with resources on a project and these resources being Engineers.

2.3 Lack of Resources

The heart of any project is the people working on the project. That is why having the correct people for the project is extremely important. Projects compete for resources against other projects and this puts the Project Manager in the position of being in competition with other Project Managers. Organisations rarely have sufficient resources to staff all projects concurrently. As such, projects compete against each other for resources, and the result is people assigned to several projects at the same time. Resources are required for every project. The size and scope of a project will determine how many resources are required. According to Rajkumar and Alagarsamy [12], there are even cases when a project is not achievable because there are insufficient resources allocated to the project. It is common for different projects to require certain resources at the same time. The team members assigned on projects are based on their availability. Some people assigned to a project may be too proud or simply are not knowledgeable enough to tell the manager that they are insufficiently trained nor have the experience to carry out their assigned work. Those with special expertise of scarce skills may be in high demand, causing bottlenecks, thus indicating a shortage of highly skilled Engineers. The most common and widely experienced challenge [13][14] is having insufficient team skills. Team skill and the lack of skills are discussed further in the next section.

2.4 Lack of Skills

Skills shortage is one of the single most weaknesses to project delivery. With this in mind, rates increase as Engineers are in demand and therefore they are able to dictate the assignment [15] they intend to work on. Engineers with basic skills are required, but there is also a need for Engineers who understand the product or project and the management thereof. Civil Engineering is one of the two disciplines that offer substantial growth in the United States of America [15], with the other discipline being Biomedical Engineering. With ageing infrastructure, the need for Civil Engineers is expected to grow by 20% from 2012 to 2022. The skills needed to complete a project are determined by the team selection [16]. The chances of getting the required skills are minimal and therefore organisations need to do more training. According to Luecke [16], the following areas of proficiency should be considered:

- Technical skills: this relates to a specific discipline or area of expertise.
- Problem-solving skills: to enable individuals to analyse difficult situations;
- Interpersonal skills: the ability to work together effectively in a team;
- Organizational skills: networking and communicating well with others.

At project inception, when resources are allocated, interpersonal and organizational skills are often overlooked, as the technical skill is perceived to be the most dominant skill required. By having individuals with all 4 skills, this will counterbalance weaknesses in the group.

Skilled Engineers are also lost during times of recession. This results in a skills' gap. Skills Gap is the difference in the skills required on the job and the actual skills possessed by the employees. Therefore, retraining and Professional development is required. There are companies that will not offer positions to Postgraduates and this makes it difficult for future Engineers with skills to develop, thus resulting in a lack of skilled Engineers for future generation. Considering that parents recommend engineering as a career, this is not filtered to the young generation [17].

For a country to develop both economically and socially, it is essential that there is sufficient engineering capacity. To ensure better healthcare, access to education and the attraction of foreign investment, basic infrastructure is required. This is the key for any nation or country to grow. In their report, Matthews, Ryan-Collins, Wells, Sillem and Wright [18], it indicated that Africa lacks Engineers with sufficient skills and

experience. The lack of scarce technical skills was also one of the challenges affecting the mining industry of South Africa. Some other challenges identified by Motsoeneng, Schultz and Bezuidenhout [19] included:

- increased global completion;
- strikes, high turnover rate;
- emigration and
- demand for productivity.

These challenges could potentially affect productivity of the mines as well as safety standards. A lack of government investment in engineering skills development; out-of-date teaching methods, lack of knowledge transfer, and 'brain drain' of engineering talent are some key causes of low skills affecting the resources in the Engineering sector. In South Africa, according to van der Merwe and Barry [20], it is estimated that between 3000 to 6000 vacancies exist for civil engineering and some reasons for this skill shortages are:

- Professionals leaving the industry;
- Professionals leaving the country;
- Inadequate education in school (mathematics and science);
- The retirement of older professionals;
- Professional fee reduction by clients, resulting in lower salaries;
- General negative perceptions of an engineering career(i.e. long working hours for little money);
- Lack of integration of minority groups and;
- Increase in the demand for new infrastructure.

Various factors contribute to the lack of skills on a project. The root cause identified in South Africa is a Brain Drain [21]. Brain Drain leaves many countries (mostly developing countries) short of the skills needed to meet the challenges of economic development [22]. Brain Drain is discussed in the next section.

2.5 Brain Drain

Brain drain is defined as the net outflow of persons from one country to another. It is the loss of the most educated and most talented workers to other countries (normally from developing countries through migration) [23]. With highly skilled people leaving a country, this becomes a problem and the country they are leaving may suffer economically due to the lack of knowledge and “know how”. If this continues on a large scale, it can threaten a country’s higher education and science system [24]. Brain Drain cannot only cost a country million in lost revenue and expertise but also a continent as migrants are seen as cheap labour in developed countries.

Globalization has been a major cause of Brain Drain [25]. The result is human capital is scarce when it is already rare and abundant when it is plentiful. Human Capital is assets that yield income over time. People escape from developing countries to developed or industrialised countries, due to the hardship in the developing country. Moreover, it is in these developing countries that skills are low.

The Push-pull theory [22] is a widely used approach to understand the brain drain and migration in general. The push factors are what make a person want to leave while a pull factor is what attracts a person to a country.

Push factors are unfavourable conditions drives people to leave. They may include, among other factors, job scarcity, low wages (financial matters), low standards of education, economic instability and political unrest [22][26].

Pull factors are favourable conditions that attract people to a country. There are incentives that a country has to make a person want to come live there. These incentives are economically and socially attractive features. They are the factors that promise a better standard of living, career growth, and better wages. Another pull factor is to further their studies abroad and the availability of scholarships offered by the host country to finance their education [26].

Why do countries (mostly developed) want people from developing countries? Many developed countries lack skilled professionals. Therefore, there is demand for skilled resources in some developed countries. The chronic resource shortage threatens economic growth of many countries. Therefore, governments, e.g. in Australia, increased its skilled migrant intake [22].

Research studies [22] have indicated that the 3 main causes of brain drain are economical, socio-political and even personal. For the purposes of this study, we will discuss the push factors, considering many developing countries have the skills needed to meet the economic developmental challenges. The most common mentioned reasons for migration are political instability and civil war. Political leaders enjoy a prolonged hold in their position and this can last for decades. This creates a convenient platform for corruption and theft. In South Africa, there has been decades of inequity and political unrest mainly due to racial conflict.

Unemployment persists in Africa and this causes the mass exodus of the educated class from the continent. With low investments in education, there are negative outcomes in the labour market. The economic development of a country is greatly affected when it is deprived of human capital and the scarcity of resources. Improvement in the political environment will reduce brain drain [25]. There is a link among factors, for instance, a corrupt government threatens political stability and contributes to a failed educational system, unemployment and poverty [26]. The top three scarce skills in South Africa are Electrical, Civil and Mechanical Engineers [27]. A major reason for this scarcity of skills is due to emigration, which results in a Brain Drain. The following occupations are on the list as being in high demand in South Africa [28]:

- Manager
 - School Principal
 - Faculty Head
 - Head of Department (Teacher)
- Professionals
 - Mathematician
 - Civil Engineer
 - Civil Engineering Technologist
 - Civil Technology Teacher (Grades 10-12)
 - Mathematics Teacher (Grades 10 – 12)
- Technicians And Associate Professionals
 - Civil Engineering Technician

These high demand occupations either directly or indirectly affect the civil engineering profession, either through training, development or as professional. With the lack of these teachers, Engineers and mentors, it is difficult to train and transfer the skills required for future Engineers. South Africa needs to urgently reverse the brain drain

of its talented researchers and raise its education and expertise, so that its own people can solve South Africa's problems.

On the 11th July 1996, Nelson Mandela expressed this so eloquently in his speech [29] to the palace of Westminster when he stated that:

“For centuries, an ancient continent has bled from many gaping sword wounds. At an Earlier time, it [Africa] lost millions of its most able sons and daughters to a trade in Slaves, which defined these Africans as fit for slavery because they were African. To this day, we continue to lose some of the best among ourselves because the lights in the developed world shine brighter”.

2.6 Overcoming the effects of skilled shortage on Projects

It is beyond the control of any organisation to rectify the effects of brain drain, as it is a countrywide problem. However, there are factors that may be considered within an organisation to ensure project success when it comes to skilled resource. The factors identified are indicated in Figure 3 and further discussed.



Figure 3: Factors to consider Project Success

2.6.1 Outsourcing versus in-house

There has been an increase in the outsourcing of engineering services in the last decade [30]. Outsourcing is divided into 2 categories. Outsourcing in terms of employing workers on contract and outsourcing of work by a company to another company. This section will cover both these types of outsourcing in further detail and the impact on resources.

There is vast difference between contract workers and permanent employees. Apart from company policies that exclude contract workers, Bidwell [31] found that contract workers were least likely appointed for longer lasting positions as it is difficult to monitor their progress, and they require more training. Services fluctuate in an engineering organisation and therefore companies use a mix of workforce of employees and independent contractors. In South Africa, some additional challenges in the engineering labour market include but are not limited to the following [32]:

- Labour unions;
- ongoing unrest and
- increased labour costs.

Due to these challenges, many companies seek to outsource activities to independent contractors as they have a better technical knowledge compared to their employees. However, contract workers are hindered by the lack of the understanding company processes.

Masters and Miles [33] found that permanent employees were more likely to perform specific skilled tasks and critical work compared to contract workers. Therefore, firms are encouraged to invest in the training and development of their people to maximise the organisations' returns. Also, with incentive schemes, this motivated permanent employees to contribute towards the organization goals.

Where there is repetition work and specific skills required, including the assessment of performance, companies are less likely to use external labour (contractors). Managers therefore use permanent employees for tasks that were more important to the organisation and required more business knowledge. This was as a result that contract workers showed less commitment to the organisation requirements [33]. On the other hand, external labourers (contractors) carried out shorter tasks resulting in internal skilled resources being over resource.

In several of the smaller municipalities in South Africa, there is a struggle to operate and maintain their infrastructure. Human resources issues have been identified [34] as being one of the challenges to service delivery. There is no capacity in the municipality to mentor young inexperienced technicians. These technicians resign very soon for better career opportunities. A solution to these problems is secondment. It is an attempt to temporarily address the lack of experienced and skilled engineers in the municipality Technical departments. The engineers and technicians seconded to the municipalities lack the knowledge of municipal engineering and in most cases, unable to assist.

In order to retain people, one needs to understand the employee's job satisfaction and the company environment (i.e. employees are comfortable) and reinforce this to motivate employees to stay. Employees will stay in an organisation, as they are in a comfort zone until some external forces causes them to leave. These factors, according Flowers and Hughes [35] vary from internal to external factors and shown in Table 1 below.

Internal	External
Job satisfaction	Job market
Job environment	personal criteria

Table 1: Internal and external factors

As internal factors are critical to keep people in an organisation, we will only discuss why companies need to keep people. Job satisfaction is about achievement, recognition and growth. The Job environment includes works rules, facilities and benefits, just to name a few. In a study carried out by Flowers and Hughes [35], showed that dissatisfied people will stay on in a company due to finances, family responsibility, lack of outside opportunity, age and in some cases "corporate enculturation" (they would not want to look for a job or have to learn new policies, or if they are in their comfort zone).

Many businesses now days outsource many functions including engineering services. Outsourcing is considered as collaborating and a non-continuous service [36]. "Partnering" has been defined by Elliott [37] as "a commitment between two or more strategically linked organizations working together to maximize their effectiveness and

reduce the total cost of their shared process”. Some major reasons for outsourcing according to De Rose and Mc Laughlin [38] are:

- Cost reduction;
- Adding expertise;
- Comprehensive services;
- Continuous improvement and
- To sharpen the strategic focus (parent company can focus on its core business).

Although outsourcing is perceived as a quick fix to improvement and lowering costs, the question still asked, ‘Is outsourcing the solution?’

Outsourcing services is different to contracting work. It entails transfer of a service/task and in most cases transfer of risks to the outsourced company. With Contracting, the risk still lies with the parent company. Organisations just want the same or better service when outsourcing, if the cost is less and effective, then the parent company will not care who does the work [38].

2.6.2 Leadership

As much as there are differences between Managers and Leaders, there are also similarities. Both Managers and Leaders manage people and their work. Managers though on the other hand would follow tasks set out by their leaders. Leaders create goals, vision and are influential. They also stimulate team member’s innovation, while Managers organises and plans. Leaders are concerned with the future whereas managers are concerned with the present. All engineers need managerial skills to get their work done [39]. Just as engineers need managerial competencies, a different set of skills are also important for leaders. Anyone can be a leader, and a leader can lead a company to succeed or lead it to fail.

Hinkle [39] identified four characteristics that differentiate a leader to a manager. Leaders are visionary/strategist; they act on intuition, build strong relationships and leave a legacy. Therefore, it is a major role for engineers to have leadership qualities. In real life situation, there is a need for skilled engineers to understand and solve problems. Today there is an immense challenge with leadership in the engineering market. Therefore, engineering leadership should be a solution to this challenge [41]. With leaderships, comes cultural intelligence. Leaders, including engineers, need to be more understanding of their team’s cultural differences. By neglecting the cultural

differences [40] in the team, the impact may have dire consequence on the success of the project.

According to the 'Dean's Task Force on engineering Leadership Education Final Report' [42] at the University of Toronto, engineering students need to address complex challenges. Leadership education is a solution to empower engineers to meet these challenges. Leadership can be taught to capable people and engineers are capable [42]. The report also stated four realms of leadership learning:

- i. Self-Leadership,
- ii. Relational Leadership;
- iii. Organizational Leadership; and
- iv. Societal Leadership.

Therefore, Engineering students will be empowered by developing their leadership skills.

2.6.3 Human Management

Project human resource management refers to how a Project Manager runs a project team. One needs to understand what resources are required to be able to successfully complete a project. After that, it is all about managing the people on the team including giving them extra skills to do their jobs and knowing what motivates them.

"Human Resources" is one of the 10 Knowledge areas in the PMBOK [5]. Each of the 10 Knowledge areas consists of a set of process and these processes, together, results in a successful project completion.

Projects fail mainly due to human nature such as conflict with colleagues, issues and poor communications [43]. Some other related issues include requirements, planning and decision-making. With multi projects organisation, various projects have different constraints related to resources.

One of the top major issue facing organizations today is resource management. For a company to have a successful business strategy, the organisation needs to increase employee productivity [44]. Globalization has led to an increase in market demands thereby creating a challenge with managing resources [45]. Changes in planned resources affect and often threaten a project.

According to Pennypacker [46], the top 10 Resource Management Challenges are:

- Resource capacity planning is poor;
- Resource risks are not assessed;
- Not enough appropriately skilled resources;
- Resource use is not optimized;
- Schedules/deadlines are unrealistic;
- Resources are assigned inconsistently;
- Too many unplanned requests for resources;
- Resource utilization is poorly documented;
- Shifting resources to respond to problems; and
- Transition process for resources is inadequate.

Having suitable resources will solve these challenges mentioned above. By applying the correct resources where there is shortage, improved delivery can be achieved. The small things matter to employees [44], e.g. their comfort in the working environment, temperature of the office, noise levels, etc. These small matters may go a long way to ensure increased employee production and their satisfaction. When changes are implemented in an organization, employee's psychological health and safety need to be taken into consideration [47] as this may affect both the organisation and the employee. Care is also critical in an organisation. Organizations need to show more care and understanding towards their employees. Managers need to understand the concept of care towards their employees and their need to succeed, as different situations require different approaches. Care can be shown in different ways. One method is to recognise and reward the top performers. By recognition and rewarding the key staff, this will motivate them further and increase project success.

2.6.4 Skills Management

The previous section briefly discussed Human Resource Management. Human resources are a vital role in the success of projects as it depends on engineers, Technicians and the like. In this section, the management of skills to enable engineers to succeed is discussed. Engineers are knowledgeable people and problem solvers. The current trend is to manage the knowledge of employees, knowledge sharing and knowledge management.

There are 2 types of knowledge according to “Dingsøy and Røyrvik” [49]; “Tacit and Explicit”. Tacit is when a person learns through experience, it is a trial and error situation. Explicit relates to examples and is represented either verbally or non-verbally, e.g. books, talks etc. Both are beneficial if used in the correct combination.

Management skills are of great importance at all levels in any organisation. Stahl [53] identified 7 basic fundamental management skills that are referred to as framework for success. These seven basic fundamental management skills include:

- Leadership and Management;
- Creating a High-Capability Organization;
- Developing People;
- Brand Positioning with Consumers;
- Customer Relationship Management;
- Financial Strategy; and
- Influencing people.

With poor management skills, there is the risk of high employee turnover, lack of training and lack of recognition. Therefore, teachers are the key element as skills management starts with teachers. If teachers at schools are motivated, they will inspire students to succeed in their chosen profession. Globalisation competes internationally for the best. The challenge is that teachers need to be global teachers and understand the requirements for future engineers. With a change in technology, the engineering curriculum at tertiary institutes also need to advance and change with the rapidly changing environment.

According Muller, Shaharabani and Shacham [48], the Ministry of Education in Israel initiated a training programme for engineers to become second career teachers. With their experience and skills, the programme was to enable these engineers to transfer their knowledge and skills to students. A decision to quit the engineering profession comes with considerable losses such as job security and decent pay. There is plenty of possibility if one chose to change direction. A teacher will leave with skills such as planning, organisation, presentation abilities, and confidence to deliver in groups and to deal with difficult situations. The aim of the program was to elevate students through motivation and give back to the society.

Nguyen [54] listed seven generic skills and attributes for the development of the professional engineer. These seven skills Nguyen is shown in Table 2.

Skills	Description
Technical knowledge and skills	This is the individuals practical ability e.g. use of modern technology
Intellectual skills	The ability for an individual to learn and comprehend new information.
Attitudes	The behaviour, thoughts and actions of an individual
Standards of engineering practice	Awareness and observance of engineering codes of practice and ethics; understanding an engineer roles; and general knowledge of the working legislation and regulations.
Business practices	Understanding of economic and financial issues, and ability to work within a business-orientated environment.
International/national history and culture	Understanding other cultures and customs.
Proficiency in languages	Understanding or being familiar with other language.

Table 2: Generic skills and attributes the professional engineer

In Nguyen's research [54], a survey was distributed to three groups. These groups included the following:

- i.) Academics
- ii.) Industry
- iii.) Students

The three groups were asked "What did they consider to be the essential skills and attributes of an engineer?" A summary of the results are reflected in Figure 4.

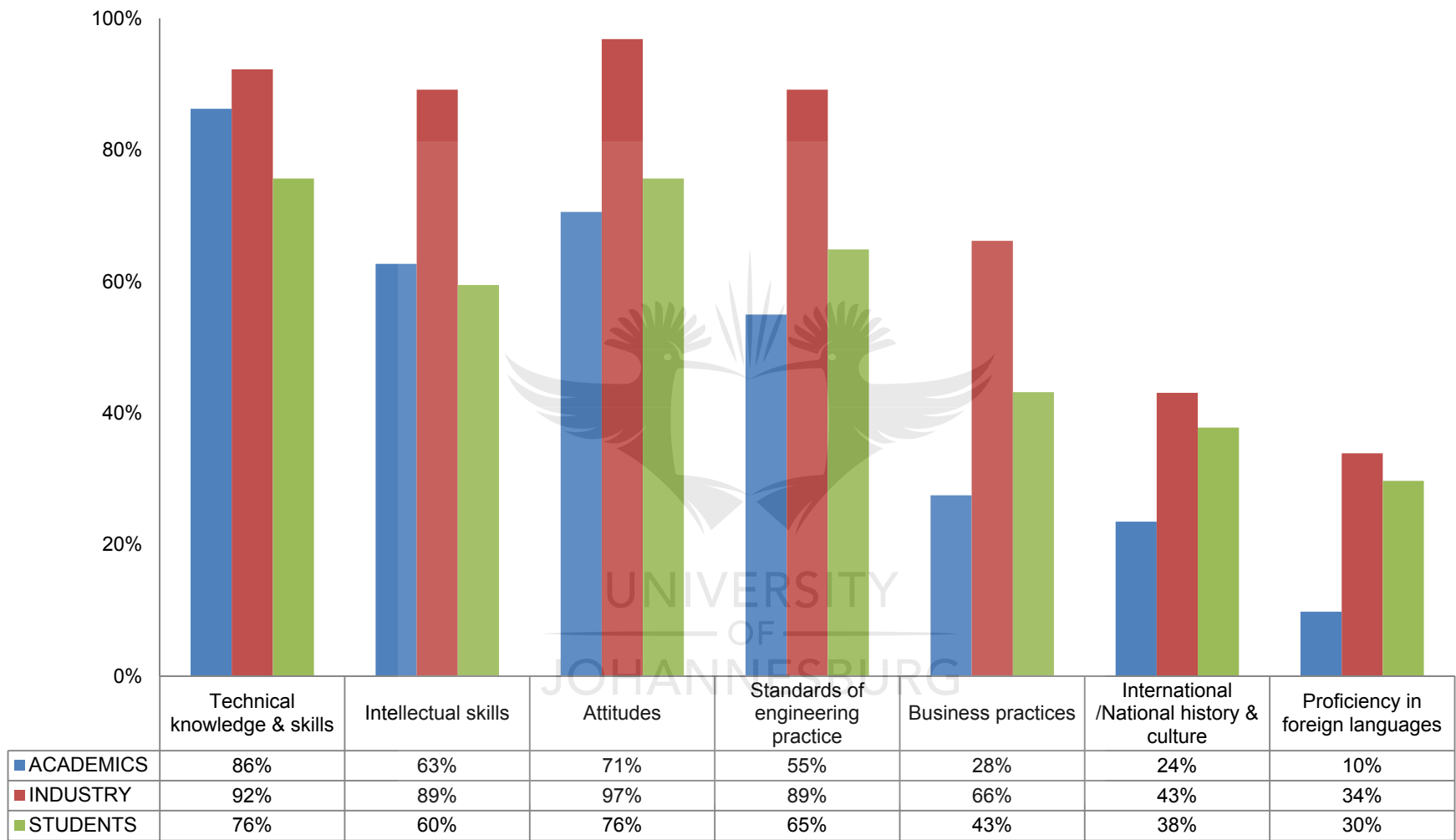


Figure 4: Essential skills and attributes of an engineer

Industry considered attitude to be of most significance (96.9%) followed by technical skills (92%); academics considered 'technical knowledge and skills' (86%) to be most important followed by attitude (71%). The students' view (76%) correlated with both the academics and industry for both 'technical knowledge and skills' and 'attitudes'. All three groups considered business practice, international/national history, culture, and proficiency in languages to be of least relevant. Therefore, based on Nguyen's research [54], the modern engineer's most important skills are technical knowledge and skills, and attitudes.



CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

A Literature review identified the challenges for resources on the successful completion of a project. Chapter two covers the gathering of this secondary data and provides information how the research was conducted. This chapter discusses the research methodology and the application of the data collection approach in the study.

3.2 Research Methodology

This research commenced with a literature review based on the topic related to a lack of resources on engineering projects. The literature review highlighted the challenges experienced with a lack of resources on projects especially in South Africa. From the literature review, it was evident that there is countrywide problem that requires immediate attention. The next step was to identify the research approach and in conducting this research involved the selection of the appropriate methodology in order to gather primary information about resources on projects in the engineering sector.

The method used was a mixed method and refers to integration or mixing of quantitative and qualitative data within a single investigation. Qualitative research method explores the opinions, beliefs, relationships and experience of people and provides information from a human side [56]. These research methods are flexible, and mostly open-ended. The responses from participants are more complex than a yes/no answer. Participants are also free to respond in their own words. Quantitative methods seek confirmation on the hypothesis. This method deals with numbers, logic and determines the relationship between variables. The target population were asked identical questions. The questions are closed-ended and this allows comparison of responses across the target population. It also looks at the relationship between the variable and test the theory. The mixed method was chosen as it provides a more realistic world view [57], and expands the research in a way that a single approach cannot. By collecting varied types of data, it provides the researcher with a more complete understanding of a research problem that either quantitative or qualitative data could not provide on its own.

A survey design (Annexure A) was used for the whole target population. Questions were carefully chosen, crafted and sequenced based on the secondary data. The goal of the survey is to derive at comparable data across the target population and the literature review so that similarities and differences are identified.

Because of the vast geographical area of South Africa, not all civil engineering organisations would be easily accessible based on the time constraints. It was decided to conduct the research at one of South Africa's largest civil engineering Companies. Being an in-house survey, it was justified to use the survey design to collect the data. This company is located throughout South Africa and is a multi-disciplinary consulting company. By performing a survey on engineers from one large organisation, invaluable data can be collected across various types of projects and project sizes. This would help in the drawing up of a detailed plan targeting similar size engineering consulting companies in South Africa.

3.2.1 Data Collection methods

There are two types of data collected, viz:

- Primary data; and
- Secondary data.

Primary data is data, which are collected for the first time, hence they have to be original in character. Secondary data are those data that have already been collected by someone else and have already been passed through the statistical process [55]. Secondary analysis involves the use of existing data, examples of secondary sources of data includes studying literature from text books, journal, other studies, etc.

3.2.2 Primary Data collection Method

A structured research questionnaire (Annexure A) was used to collect data through self-administration. A self-administered questionnaire is designed specifically to be completed by a respondent without intervention by the researchers collecting the data. Table 3 summarizes the advantages and disadvantages by Cooper and Schindler, [50] of a self-administered survey.

Advantages	Disadvantages
Allows for contact with otherwise inaccessible participants	Can have slow response rates
Lowest cost option	No interviewer present to answer questions
Expanded geographic coverage at low cost	Cannot be long and complex
Requires minimal staff	Accurate mailing list needed
Perceived as more anonymous	Anxiety amongst some participants
Allows persons to think more about the questions	Directions needed for progression through survey
More complex instruments can be used	Computer security needed
Fast access to the computer literate	Need for a low distraction environment for survey completion
Rapid data collection	
Visuals may be used	

Table 3: Self-Administered Survey Advantages and Disadvantages

The self-administered survey was decided for the following reasons:

- Cost effective;
- The lowest labour intensive option;
- Expanded geographic coverage at low cost;
- Viewed to be as the most anonymous survey, hence the data provided should be most accurate;
- Requires minimal staff; and
- Rapid data collection

In order to get an unbiased feeling from engineers and Project managers, it was decided that all survey questionnaire administration are anonymous and confidential, thus ensuring accurate answers.

3.2.3 Ethics of research

Ethics symbolizes communal and individual codes of conduct established on the compliance of implicit or explicit principles [50][51]. The University of Johannesburg granted ethics clearance for this study. The data collected from the interviews is treated as confidential, hence the names of the participants and the organization remains anonymous.

3.2.4 Data Gathering Process

The survey questionnaire was constructed using the theory drawn from the literature review. The questionnaire used as part of the survey is attached as Appendix A. The interviewing schedule (questionnaire) was structured into 8 categories as follows:

- **Category 1: Introduction Questions**
This part of the questionnaire requested for the general information and some demographic background. The questions considered included age of respondent, their qualification, number of years of experience and location.
- **Category 2: Project Failure Challenges**
These questions were closed-ended and respondents asked what were the major project challenges and the factors that cause projects to fail due to its resources.
- **Category 3: Skills Shortage**
This section covered closed-ended questions relating to skills shortage.
- **Category 4: Brain Drain**
This section had a combination of opened and closed-ended questions. The major causes of Brain drain and the resultant impact of Brain Drain.
- **Category 5: Outsourcing versus In-house**
The questions in this section were a combination of open-ended and closed-ended questions. This category was to obtain an indication from respondent whether contract or being permanent was preferred and the implication thereof.

-
- **Category 6: Leadership**
Questions in this category was to obtain an understanding from respondents on how they viewed the difference between leadership and managerial. These questions were closed ended questions.
 - **Category 7: Human Management**
These questions were closed-ended question and were related to resources on a project and understanding the needs of resources.
 - **Category 8: Skills Management**
In this section, respondents were asked the number of current projects that and the challenges they face. These Questions were predominantly open-ended questions in order to obtain a better idea of the situation.

3.2.5 Data Analysis Process

An online questionnaire survey was utilized to collect data for this research study. The survey data was collected using “Survey Monkey”. The survey invitations were sent to an organisation that consisted of approximately 700 employees. Respondents had 2 weeks to complete the survey. The output of the survey was then analysed using Excel for the closed ended questions. Opened-ended Questions were categorised into different themes and coded. Major trends and patterns were identified and the summary produced.

3.3 Summary

The selected research methodology and approach is discussed. Based on the literature review conducted, a questionnaire of 31 questions was developed, 21 questions were closed ended questions and 10 of the questions were opened questions. The questionnaire is located as Annexure A. The survey data was collected using Survey Monkey (www.surveymonkey.net). The survey was sent out to all the employees in this organisation that consisted of approximately 700 employees.

CHAPTER 4: ANALYSIS OF DATA AND DISCUSSIONS OF FINDINGS

4.1 Introduction

The previous chapter (Chapter 3) discussed the research methodology of the study. A mixed method was chosen, and data collected was in the forms of online survey questionnaires. The survey was designed on Survey Monkey and the survey link was emailed to all participants to complete in one engineering Company as an in-house investigation. In this chapter, the findings on challenges facing projects due to the lack of resources are presented and discussed. The results are presented in the form of charts (pie and bar charts), tables and trends and patterns were summarized. The survey was split into 8 categories, as shown in

Figure 5 and this follows the same format of the literature review:

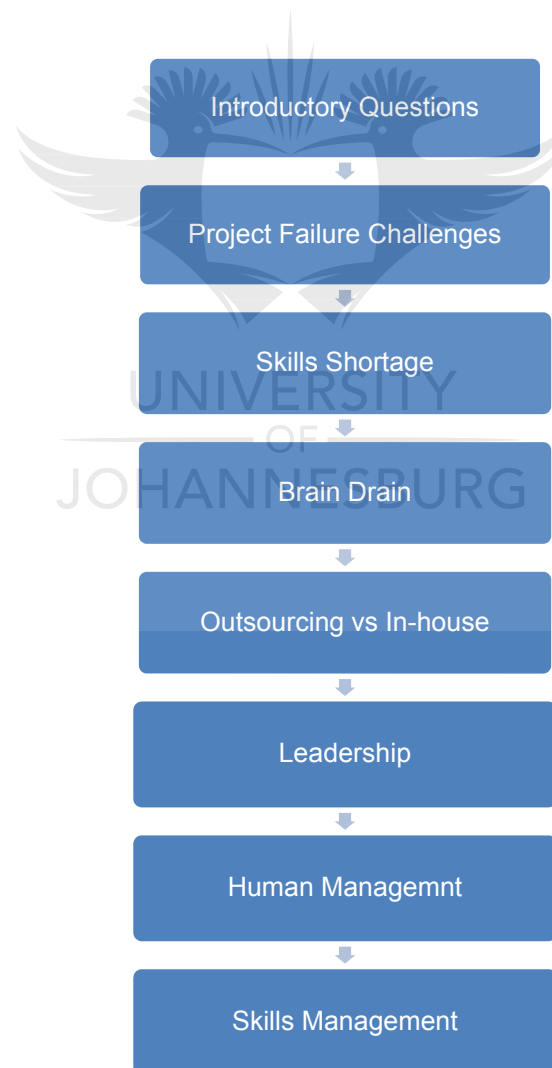


Figure 5: Survey Categories

As mentioned in the previous chapter, a survey questionnaire was used to collect data for this research. The survey comprised of both, closed and opened ended questions. The closed ended questions consisted of:

- Dichotomous (yes – no)
- Multiple Choice – a combination of one or multiple responses and
- 5 Point Likert Rating Scale

4.2 Research Questions and Analysis

The survey link was emailed to a large South African owned Consulting engineering organisation that employs approximately 700 personnel. The split between technical and non-technical personnel at the organisation is shown in Figure 6 and consists of 30% non-technical and 70% technical personnel. Technical staff constitutes, engineers, Technicians and Project Managers. Non-Technical refers to the support services (Finance, Human resource, Admin, IT, etc.).

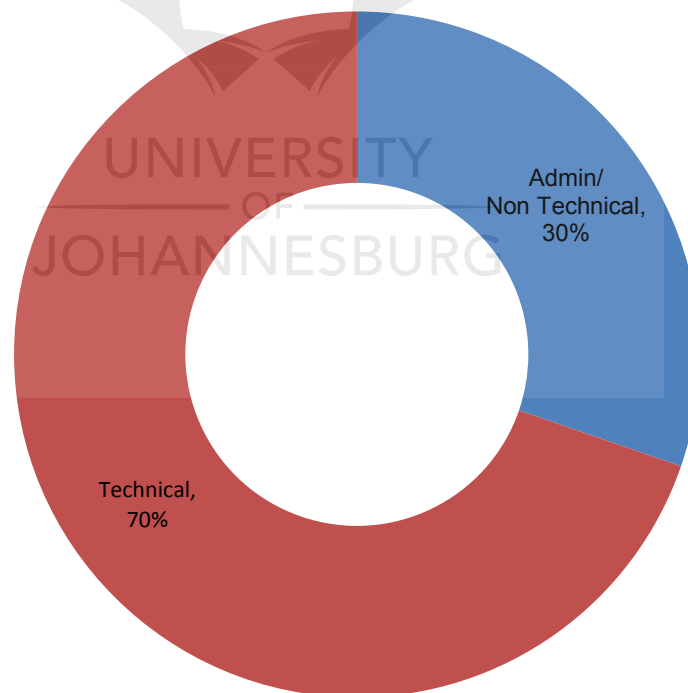


Figure 6: Non-Technical and Technical Staff

One of the major challenges experienced was ensuring that majority of the staff completed the survey. A reminder was sent to all staff 10 days after the first notification. Only 77 responses were received out of 700 target respondents. This equates to an 11% response rate from the total respondents. Previous data from the company revealed that this response is substantial considering that the responses received for surveys carried out by the organisation averages to about 7%. Therefore, based on this average response rate, it is acceptable to draw a significant conclusion of the study.

The response rate is shown in the Figure 7. On the first day, 4% responded. On the 10th day, all personnel were reminded that the survey was still open and that by the 14th day, the survey will be closed. As it can be noted, that following the reminder on the 10th day, there was an increase in the responses received.

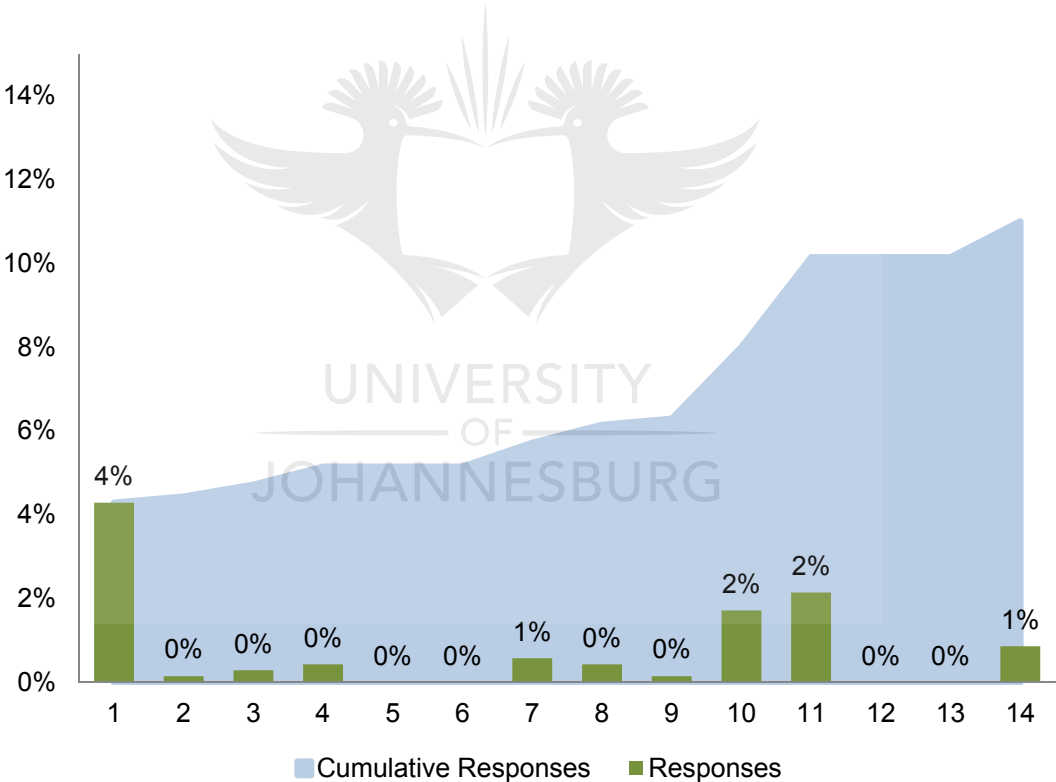


Figure 7: Survey Response rate

4.3 Preliminary Analysis of the Data

Introductory Questions

Question 1. What age category do you fall in?

The multiple choices of answers were:

- 20 – 34 years
- 35 – 49 years
- 50 – 64 years
- 65 and older

Figure 8 indicates the age category of the respondents. The majority of the respondents were between the ages of 35-49 years (49%), while the percentage of respondents in their early adulthood (Ages 20-34) was 27%. Responses from senior staff (ages 50-64) were 20%, while respondents over the age of 65 were 4%.

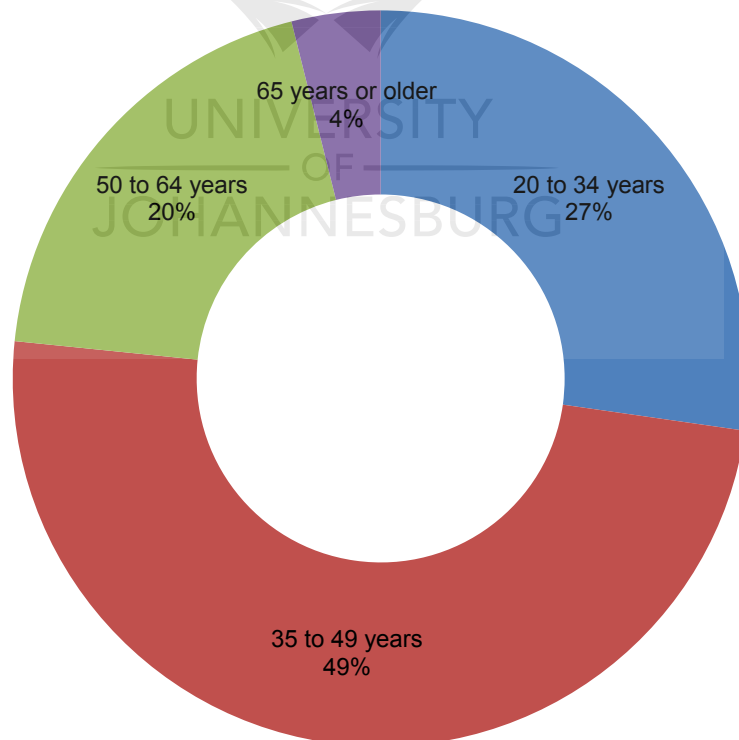


Figure 8: Age Categories

Question 2. What is your Job Title?

The selections of answers that respondents could choose were:

- Project Manager
- Assistant Project Manager
- Technical Lead
- Engineer
- Technologist
- Graduate engineer
- Technician
- Other

Most of the responses received were from engineers (26%), followed by equal responses (13%) from Seniors Managers, Technologists and Technicians as shown in Figure 9. Assistant Project Managers (1%) and Graduate engineers (5%) were least employed in the company and therefore the percentage of from these respondents are lower.

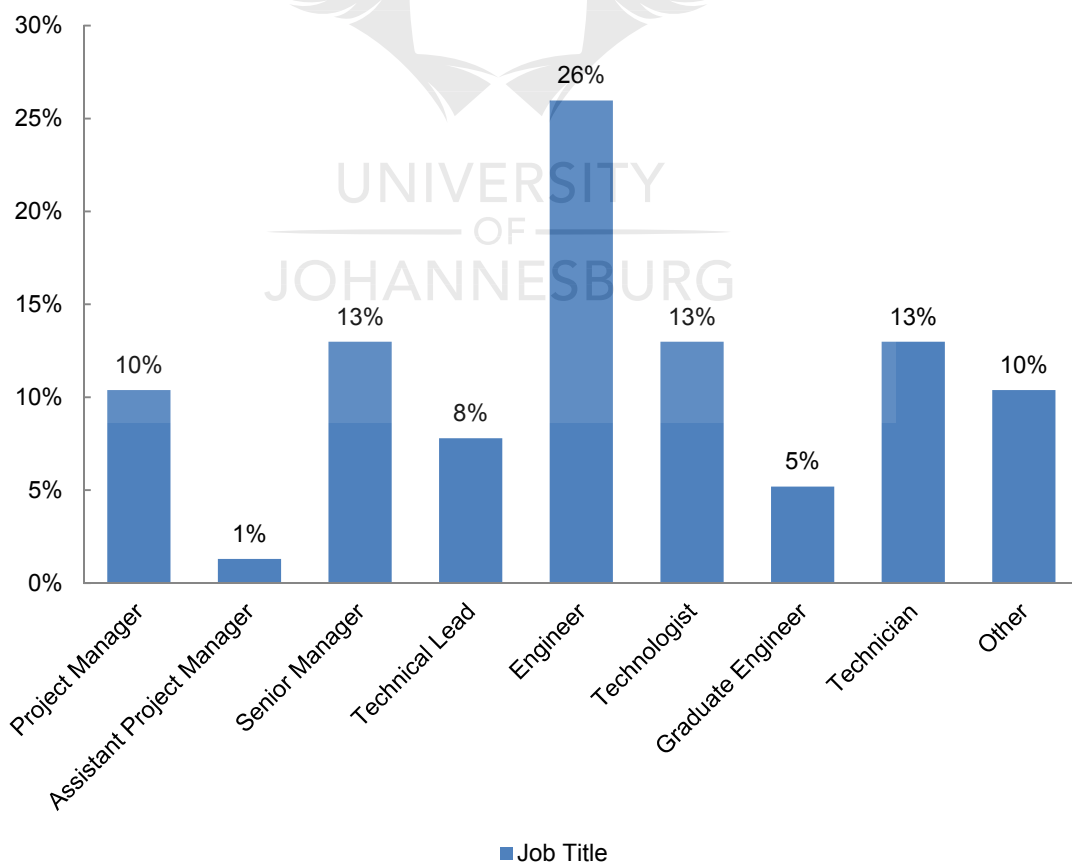


Figure 9: Job Title

Other job titles included, Project Planners, Project Administrators, Resident engineers and Draughtsperson as shown in Figure 10 . Project Administrators made up 50% of the total 'Other' Job titles.

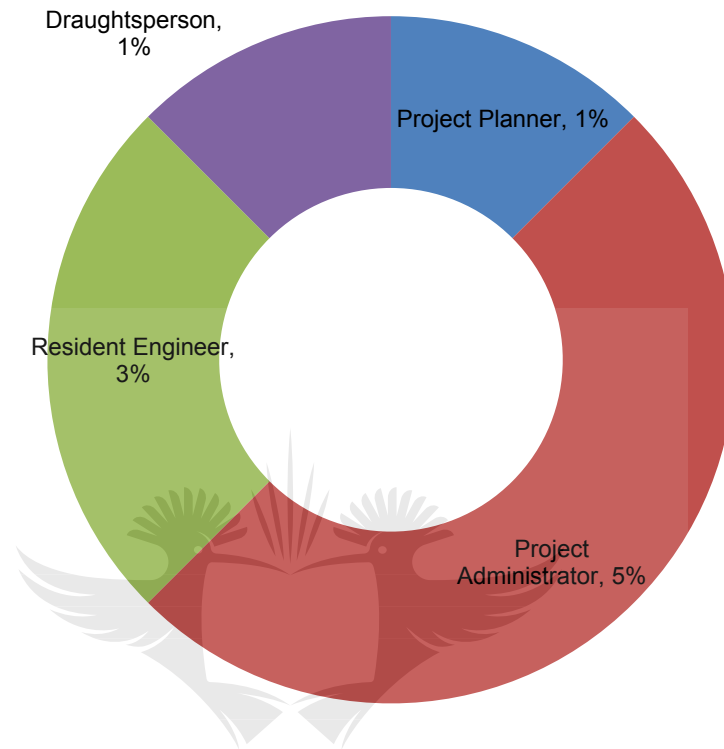


Figure 10: Other Job Titles

Question 3. How many years of experience do you have in your field of expertise?

The following options were provided:

- 0 – 5 years
- 6 – 10 years
- 11 – 15 years
- 16 - 20 years
- 21 -30 years
- More than 30years

The responses received for the number of years of experience in the field of expertise are shown in Figure 11. Most of the respondents (20%) have 6 to 10 years of experience, followed by 18% of the respondents that had between 21-30 years of

experience. Only 13% of the respondents have 11 to 15 years of experience and 15% have up to 5 years of experience.

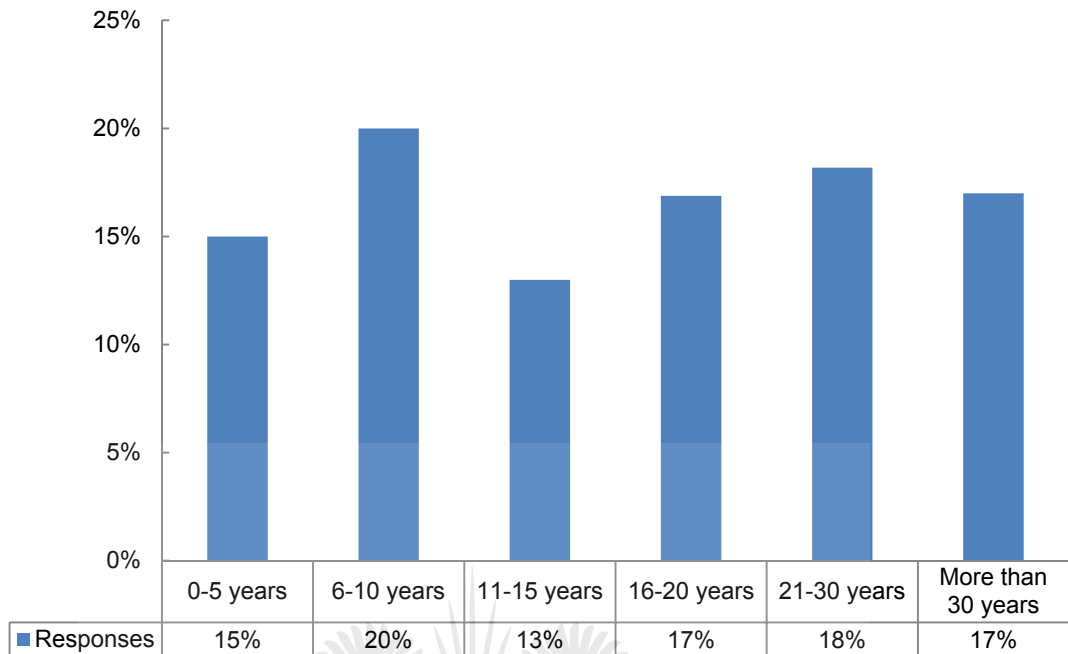


Figure 11: Years of Experience in field of expertise

The above data was further analysed and split into the various ages groups (based on the responses in question 1). Figure 12 indicates the percentages of responses from the various age groups and their years of experience. The highest responses (17%) were between the ages 35 and 49 years with 15 to 20 years' experience. 14% of the respondents between the ages of 35 and 49 years had 21 to 30 years of experience. Also, 14% of the respondents between the ages of 20 to 34 years had 0 to 5 years of experience. There were 12% of the respondents between the ages of 50 and 64 years with more than 30 years of experience.

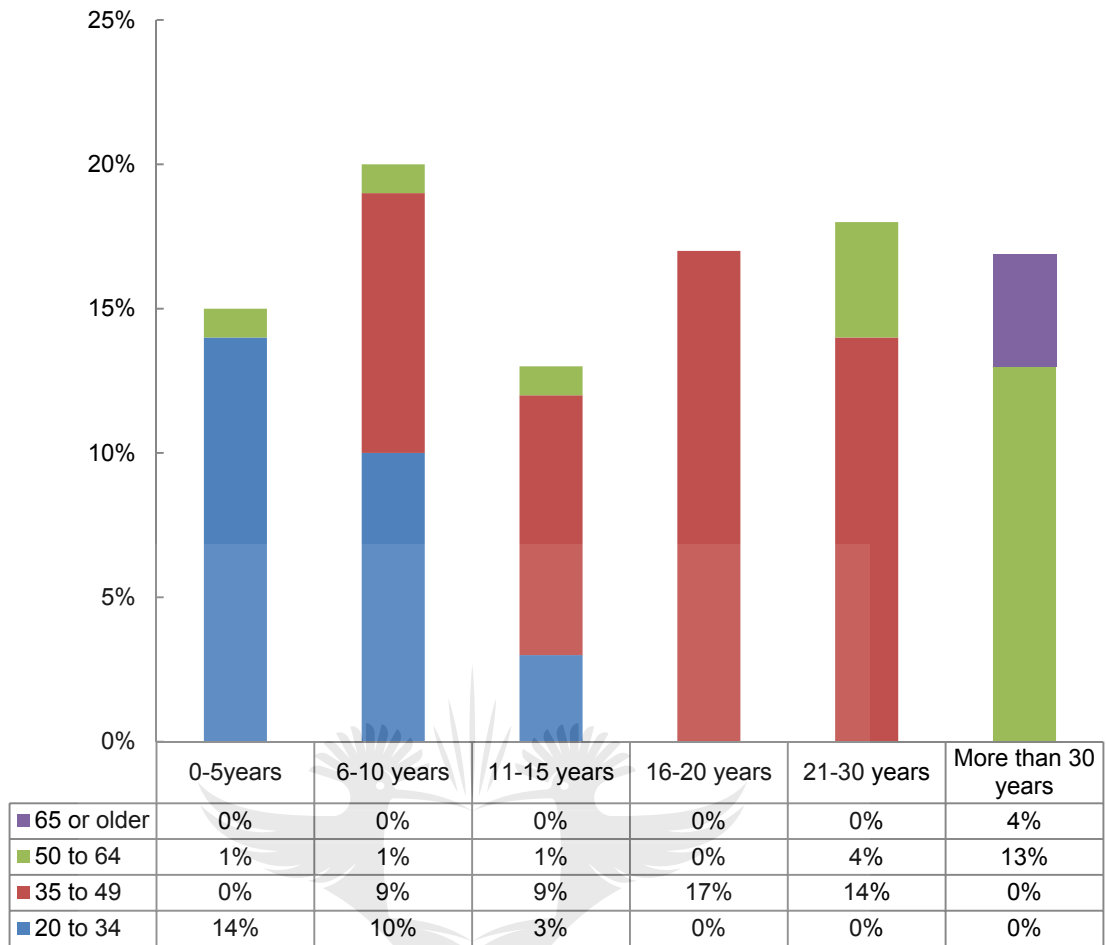


Figure 12: Responses from the various age groups and the years of experience

Question 4. Select your current work location.

The following provinces were available in the survey questionnaire:

- Eastern Cape
- Free State
- Gauteng
- KwaZulu-Natal
- Limpopo
- Mpumalanga
- Northern Cape
- North West
- Western Cape

As depicted in Figure 13, the responses received from Gauteng were the highest (55%), followed by Eastern Cape (19%) and Western Cape (19%). The responses from KwaZulu-Natal were 6%. No responses were received from other provinces.

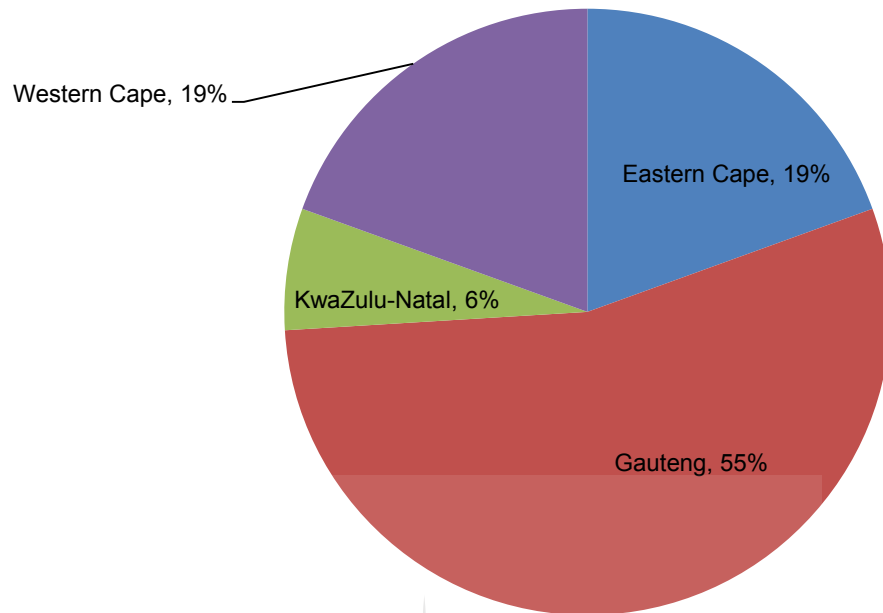


Figure 13: Current Work Location

Question 5. What are your Qualifications?

The following provinces were available in the survey questionnaire:

- Grade 11 or standard nine and below
- Matric
- Certificate
- Diploma
- Bachelor's degree
- Post-graduate degree or diploma
- Other

The majority of the respondents had a Degree in Engineering (32%), followed by Bachelors Degree in Engineering Technology (19%), as depicted in Figure 14. The Other qualifications, as shown in Table 4 varied from Honours in Engineering, Masters in Business Administration (MBA) to National Trade Certificate (NTC) 3.

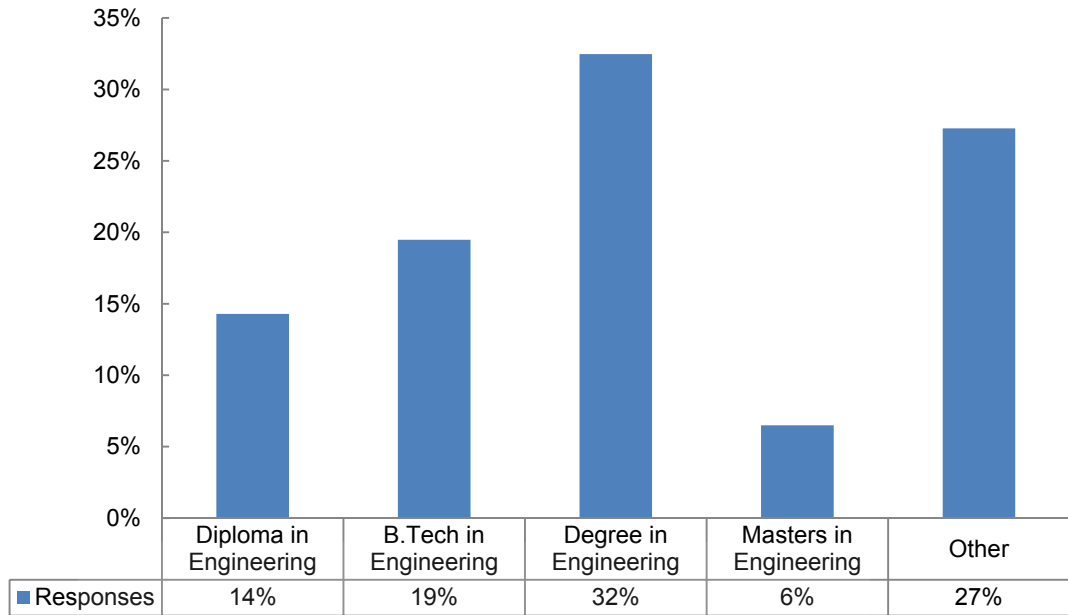


Figure 14: Highest level of Education

Other Qualification	% Respondents
Honors in Engineering	4%
MBA	3%
Certification in Project Management	1%
Diploma in Project Management	1%
Quality Management	1%
Doctorate in Business Leadership	1%
BA Industrial Psychology/ Communications	1%
Diploma in Road Transport Management	1%
Doctorate in Engineering	1%
Teachers Diploma, Project Management Fundamentals	1%
PhD in Civil Engineering	1%
NTC3	1%
Diploma	1%
Diploma BMA and Diploma Project Management	1%
Masters in property development management	1%
Masters in Urban and Rural Planning	1%
BA degree	1%
In service training	1%
TOTAL	27%

Table 4: Other Qualifications

Project Failure Challenges

Question 6. Every project is different and therefore there are several reasons why projects fail and every failed project will have its own set of constraints and causes. Sometimes, it can be a single trigger that leads to failure, but often, it is a complex set of problems that combine and cumulatively result in failure. In your experience, which of the following are major challenges when working on projects?

The following choices were available:

- Incomplete Requirements
- Lack of user involvement
- Lack of Resources
- Unrealistic Expectations
- Lack of Executive Support
- Changing Requirements & Specifications
- Lack of Planning
- Didn't Need it Any Longer
- Lack of IT management
- Technical Illiteracy
- Other




Figure 15 indicates the analysis of responses received. Respondents were able to choose a maximum of 3 challenges in the survey. The lack of planning (49%) was considered the greatest challenge on projects by respondents, followed by change in requirements and specification (48%). 44% of the respondents felt that unrealistic expectations was challenge when working on projects. The lack of resources was the fourth highest (39%) challenge associated with project failure. Respondents felt that the lack of IT management (10%) and did not need it any longer (3%) were the least of the challenges experienced when working on projects.

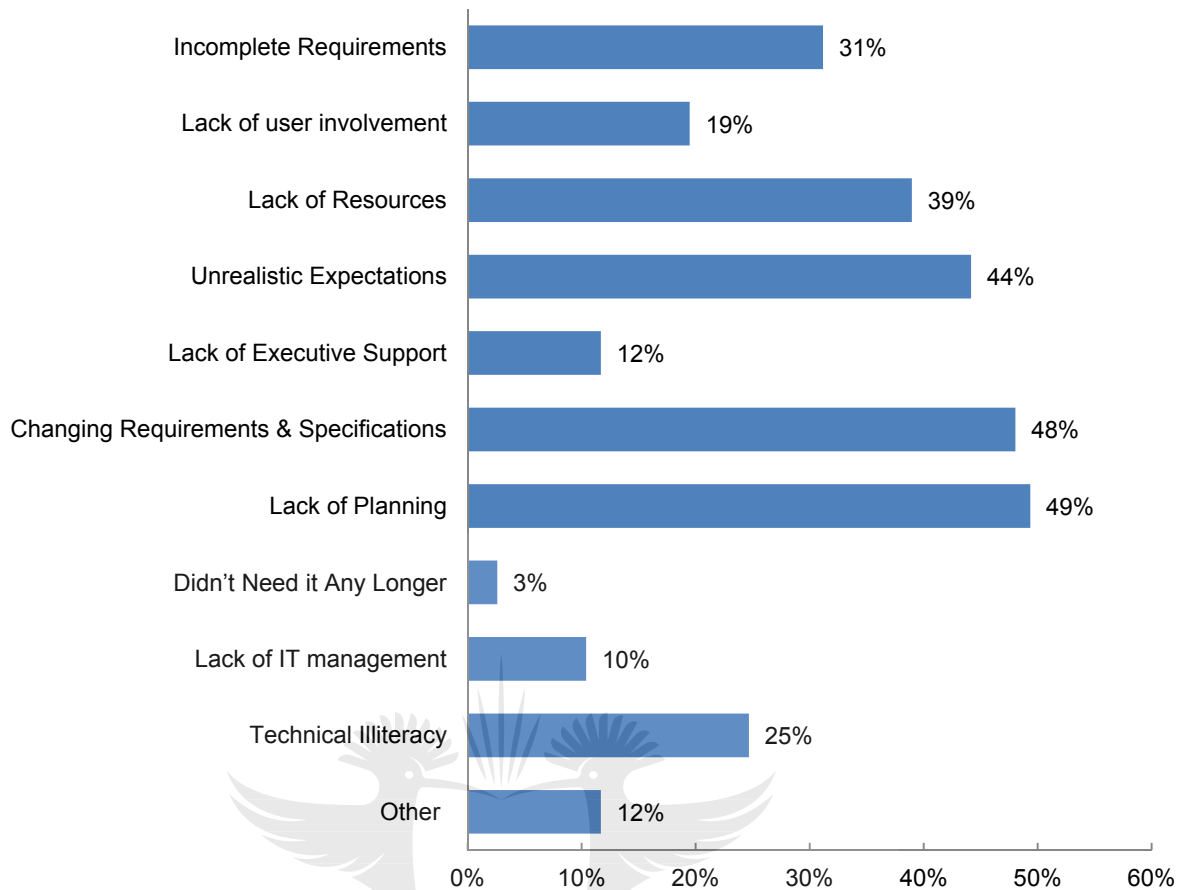


Figure 15: Challenges when working on projects

Respondents also highlighted other challenges, namely:

- Budget constraints on projects;
- Unclear Scope ;
- Community/ Political interference;
- Time and poor management;
- Legislative limitations;
- Lack of communication; and
- Internal process and procedures are time consuming.

Comparing the results by Attarzadeh and Ow [8] to the survey data, the lack of planning increased as being the major factor for a project to fail. The following factors were considered as being important challenges as they still ranked high by the respondents in both surveys:

- Incomplete Requirements
- Lack of Resources

-
- Unrealistic Expectations
 - Changing Requirements & Specifications

Technical illiteracy was considered to be the major challenge by respondents in the survey data compared to Attarzadeh and Ow [8] respondents.

Question 7. Resources on projects are the common factor for projects to fail. In your experience, which one of the following holds the greatest challenge when it comes to resources?

The following choices were available:

- Change: Change in the scope may result in a lack of resources, as they may be needed on other projects. Change in the resources (needed on another project or resignation from the organisation) can affect the project.
- Scheduling: Failure to meet the project schedule can result in increased costs because of human resource downtime. The project team did not follow the schedule that was established.
- Funding: results in failure due to inadequate funding for the correct resources.
- Resources: A project can fail due to the incorrect or insufficient resources used on the project.
- Incentives: Engineers/Resources feel that they are not motivated on successful completion of a task.
- Other: (please Specify)

Respondents rated 'Scheduling' (29%) as the most common challenge with resources, followed by 'Change' (23%) as shown in Figure 16. 'Resources' was rated as the third highest (17%) challenge. 'Funding' (13%) and 'Incentives' (12%) were not perceived as a major challenge.

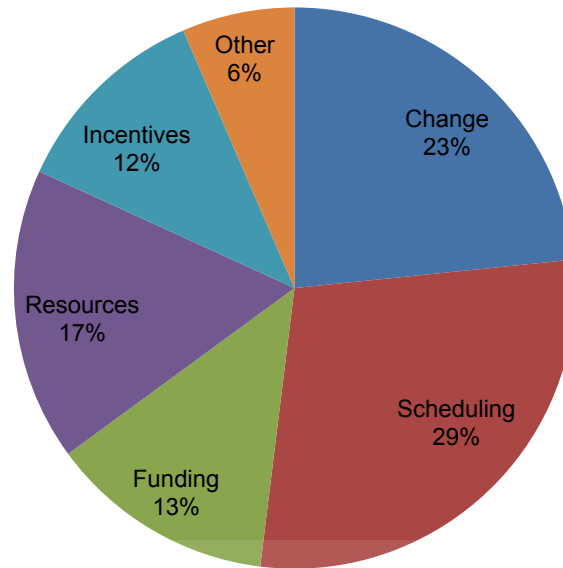


Figure 16: Greatest challenge with Resources

Respondents also highlighted other challenges with resources, namely:

- not having an integrated team or project office
- Inadequate planning
- Poor Communication

Questions on Skills Shortage

A skill shortage is when any one of the following situations arises or a combination of them:

- Shortage of workers in a particular occupation;
- Labour demand exceeds availability of skills, or workers; and
- Lack appropriate qualifications.

Question 8. The heart of any project, and the true engine of its work, is its resources. That is why bringing together the right people is extremely important. Although the skills needed to accomplish the work is determined by the team selection, it is unlikely that you will get all the expertise you need without providing some training. Consider the following areas of proficiency. Provide a rating for each of the following:

- Technical skills in a specific discipline, such as market research, finance, or software programming;

-
- Problem-solving skills enabling individuals to analyse difficult situations or impasses and to craft solutions;
 - Interpersonal skills, particularly the ability to collaborate effectively with others; a critical aspect of team-based work; and
 - Organizational skills, including networking, communicating well with other parts of the company, and navigating the political landscape, all of which help the team get things done and avoid conflicts with operating units and their personnel.

Respondents could rate this question using the 5-Point Likert scale, from 'Extremely Important' to 'Not important'. Respondent's ratings are shown in Figure 17. Problems solving skills was rated the highest (61%) as being extremely important compared to the other skills (Technical, Interpersonal and Organizational). Technical Skills, was not seen as being extremely important based on the responses received, 38% of the respondents rated technical skills as extremely important, while 26% of the respondents rated technical skills as important. A small percentage (1%) of the respondents rated technical and organizational skills as being not important, while 1% rated Technical skills as being not applicable (N/A).

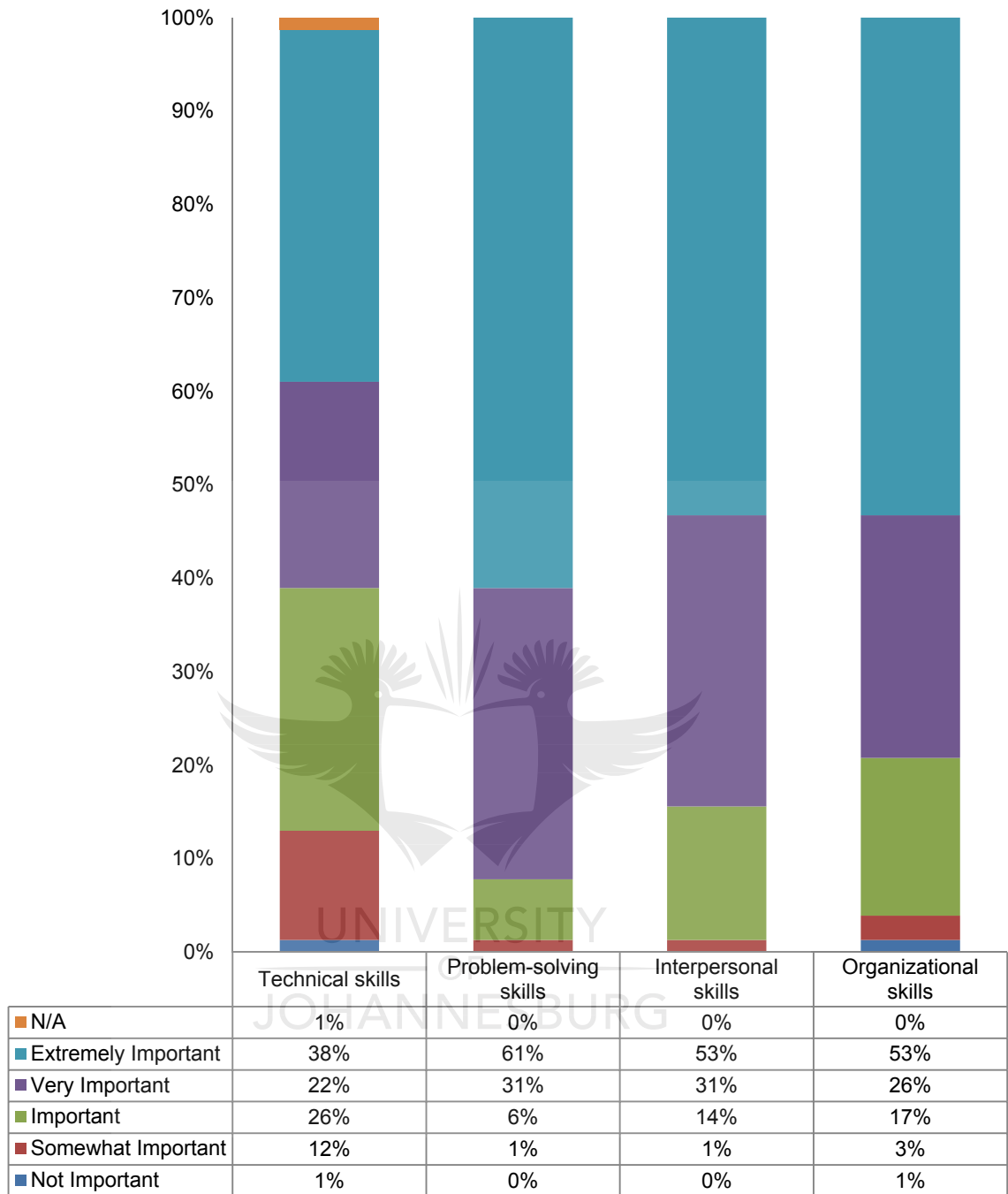


Figure 17: Skills Proficiency

Question 9. South Africa is presently experiencing a serious shortage of skilled workers. This situation is negatively affecting the economic prospects and global participation of the country. The failure of the national education and training system to supply the economy with much needed skills required to support economic growth and job creation. Various factors result in serious skills shortages in this country. The above problem is appropriate as it encompasses the core situations that may give rise to skills shortages in this country. Select not more than 3 factors that contribute extensively to the shortage of skills in South Africa:

The following choices were available:

- Globalization;
- A dysfunctional education system; or poor education standards (Inadequate education in school (mathematics and science));
- Emigration;
- Crime;
- HIV;
- Structural changes in the labor market;
- A general under-investment in skills development;
- Professionals leaving the industry ;
- The retirement of older professional;
- Professional fee reduction by clients, resulting in lower salaries;
- General negative perceptions of an engineering career(i.e. long working hours for little money);
- Lack of integration of minority group;
- Increase in the demand for new infrastructure; and
- Other

The analysis for question 9 is shown in Figure 18. The skills shortage identified, as being the major contributor by the respondents were professionals leaving the industry (48%). A dysfunctional education system (45%) was the second highest contributor to the skills shortage. While 32% of the respondents identified emigration as being a contributor to the skill shortage in South Africa, 31% of the respondents rated professional fee reductions by clients to be a reason for the skill shortage. 6% of all respondents rated globalization as being a result of the skills shortage and HIV had no impact on the skills shortage.

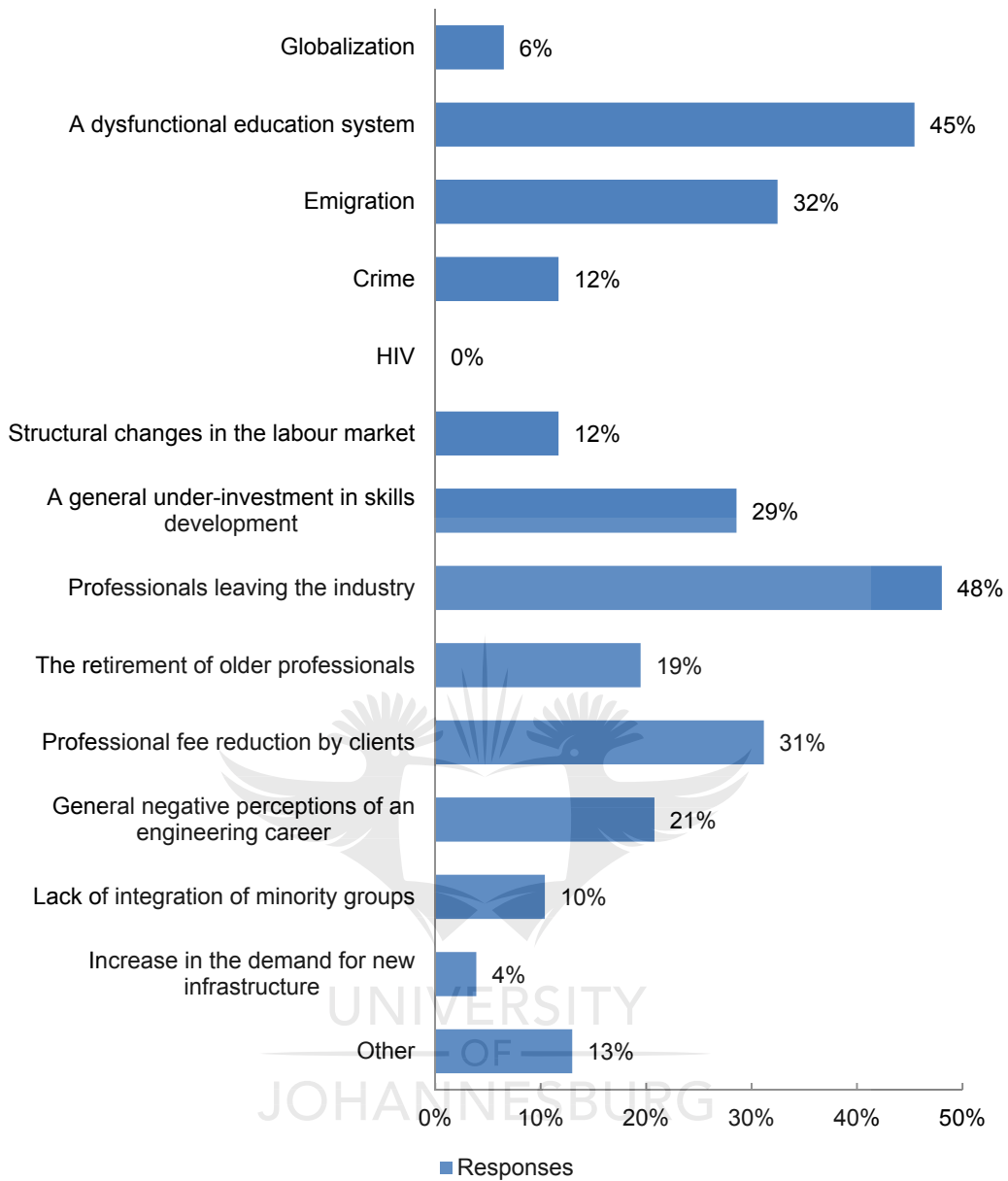


Figure 18: Factors that contribute to the shortage of skills in South Africa

The other factors that respondent identified that contributed to the skills shortage in South Africa is listed in the Table 5. Of the 13%, 7% of all respondents felt that Broad-Based Black Economic Empowerment (BBBEE) was one of the major factors that contributed to the skills shortage. Other factors included downturn in economy (1%), poor utilization of key resources, no mentorship, lack of infrastructure investment, skills not valued and lack in training.

Other	Percentage %
Downturn in economy and the resulting lack of challenging work	1%
Poor utilization of key resources and momentum work	1%
No Mentorship	1%
Lack of infrastructure investment by Government	1%
BBBEE	7%
The skills are not valued by society	1%
Lack in training	1%
TOTAL	13%

Table 5: Other Factors that contribute to the shortage of skills in South Africa

Questions relating to Brain Drain

The Push-pull theory is a widely used approach to understand the brain drain and migration in general. The push factors are what makes a person want to leave while a pull factor is what attracts a person to a country.

Question 10. What is the major cause of Brain Drain?

The following choices were available:

- Under Employments
- Economic under development
- Low wage/Salary
- Political instability
- Over production and under utilization
- Lack of research and other facilities
- Lack of freedom
- Discriminating in appointment and promotion
- Poor working facilities
- Lack of scientific tradition and culture
- Unsuitable institution
- Desire for a better urban life
- Desire for higher qualification and recognition

- Better career expectation
- Lack of satisfactory working conditions

As depicted in Figure 19, the breakdown of the analysis shows that political stability (43%) is major cause of 'Brain Drain' according to the respondents. The second major cause was discriminating in appointment and promotion (19%); followed by "low wage and/salary" (14%). Only 8% of the respondents rated economic under development as being a cause to Brain Drain, while 5% of the respondents' reason to leave was the desire for a better urban life. The lack of employment (1%) and lack of scientific tradition and culture (1%) was rated the least and perceived to have no impact on the Brain Drain. Other causes included corruption at government level and seeking a safer environment due to crime.

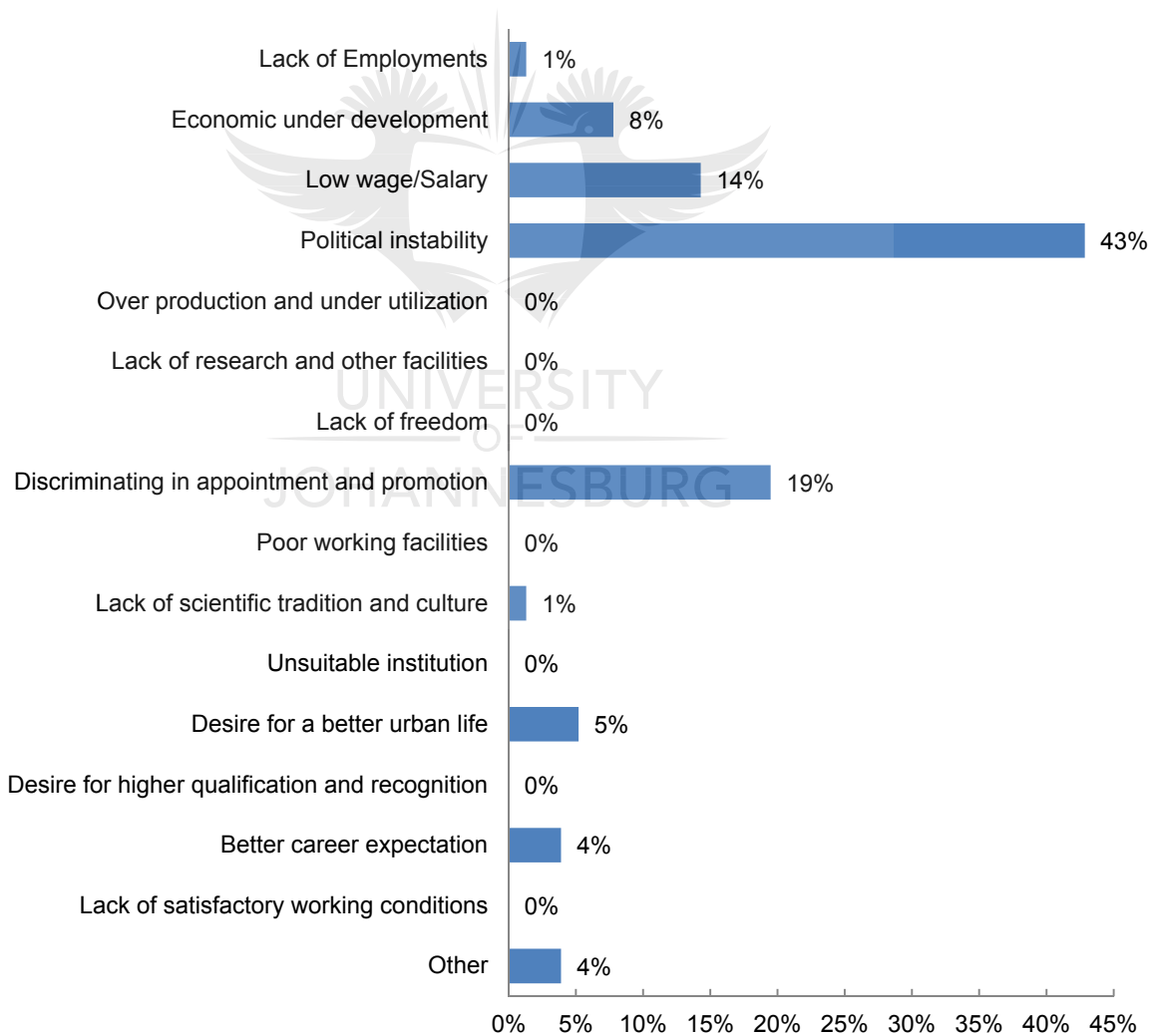


Figure 19: Major cause of Brain Drain that makes a person want to leave a country

Question 11. Based on your answer in the question above, what is your reason for selecting your response?

Based on the responses in Question 10, it is evident that the main cause of Brain Drain is Political instability (43%). Economic under development (8%) is also a cause of political instability as highlighted by the respondents.

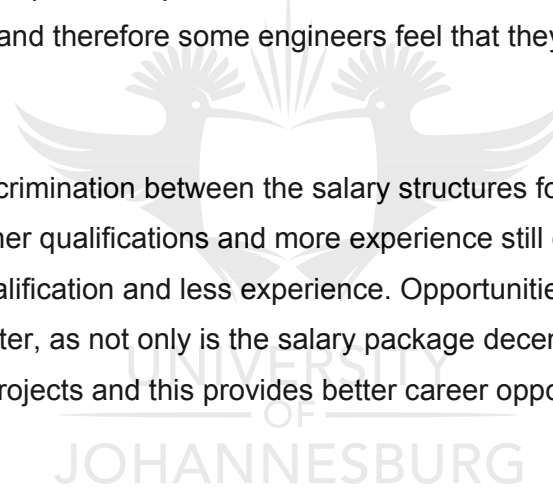
South Africa is a country in which political situation has a large impact in its people and the ability for South Africans to meet their needs. Political interference can result in interest rate hikes and in some instances job losses that may affect people and their families to meet their needs and afford the basic necessities such as food and transport. Individuals that have the financial security are able to either survive or emigrate in order to have stability, security and access to better opportunities. Political instability has a negative effect on the economy and social environment of the country. It has a secondary uncertainty regarding infrastructure spend safety/security. The result is that projects are delayed and the funds are depleted before the project is complete. The present government situation and the economic recession in South Africa have a huge impact on, not only its people but also engineering development and infrastructure requirements. Corruption at Government and Municipal level resulted in poor infrastructure planning and implementation. Government and Municipalities are not prioritizing the critical projects but implementing projects that suite their preferred service providers. The progress of a project is also hindered due to unforeseen demonstration, strikes and riots. With the Economic underdevelopment, declining Gross Domestic Product (GDP) growth, recessionary climate and junk status, the lack of engineering projects has a negative effect in uplifting an engineer's career and their professional development. In addition, with the current government structure being unstable, foreign investors are hesitant to invest in SA. Therefore, the engineering market is mostly affected directly by governance of the country and can lead to people leaving our country for another country (Brain Drain).

This second major cause of the Brain Drain is discrimination, appointment and promotion. BBBEE was launched in South Africa in 2003 and its mandate was to ensure that there was an increase in the number of Black people that own, manage, control and gain employment in South Africa's economy. With this legislation in place, the minority White group with skills are not given the opportunity to utilize their skills to their full potential.

BBBEE regulations makes it difficult for white engineers, who make up a major portion of the experienced engineers in SA, to gain employment and more specifically an equity stake in the business that they work for. There are no career path / promotion prospects for White people. Moreover, race is considered more important than skills and experience. Due to this BBBEE, many white professionals leave the country because of zero opportunities and no possibility for promotions. Promotions and appointments are based on gender and race and the ability and skills but preference is given to Black employees to meet BBBEE mandates.

The salary package of an engineer is also of concern for various reasons. An engineer's salary is not based on their efficiencies, capabilities and skills, but purely on their qualifications. Considering the amount of effort and dedication given to a company, employees are not compensated accordingly. In South Africa, engineers feel that they underpaid. The professional fees for the various built environment discipline varies and therefore some engineers feel that they are not compensated accordingly.

There is also discrimination between the salary structures for men and women. Women with higher qualifications and more experience still earn less than a male with lower level of qualification and less experience. Opportunities in the first world countries are better, as not only is the salary package decent but one also gets to work on bigger projects and this provides better career opportunities and upward mobility.



Question 12. What is the resultant effect of Brain Drain in an organisation (people migrating from South Africa to other countries)?

The resultant effect of Brain Drain may affect an organisation by the loss of their skilled employees and/or impacts negatively on a project. The first and most important effect is the loss of skilled employees. This puts additional pressure on existing employees that may not have the requisite skills, in order to meet deadlines and may result in a poor quality of standard of deliverables. The other impact is the training, mentoring and knowledge transfer from these skilled employees to the junior employees. In some instance, new engineers will be recruited in a short space of time to fill the gap and these engineers may not have the relevant skills. This may have an impact on the project and business, in that the same task carried out by the skilled engineer, will now take longer, resulting in increased cost and subsequently profit loss.

The second impact of Brain Drain is on the project itself. With change in employees, project delivery may be delayed. More effort is now spent on projects, resulting in budgets being exceeded. After loosing their core skilled and competent engineers, companies may have to spend time and money to regain this loss.

Question 13. Pull factors are favourable conditions that attract people to a country. These are advantages or the pros that a country has to make a person want to come live there. What would be some of the pull factors that would attract you to a country? Multiple selections are available.

Respondents could choose from the following choices:

- Potential for employment;
- Bitter service provision;
- A safer atmosphere;
- Low crime rates;
- Fertile land;
- Good food suppliers;
- Less risk of natural hazards;
- Greater wealth or affluence;

- Political security;
- A more attractive climate; and
- A more attractable quality of life.

As illustrated in Table 6, 43 respondents (56%) indicated that the potential for employment was the most important pull factor. 42 respondents (55%) indicated that low crime rates were the second most important advantage of a country. In addition, 42 respondents (55%) indicated that a more attractable quality of life was a pull factor. 35 respondents (45%) indicated that political security was also a pull factor that would attract them to a country while 34 respondents (44%) want a safer atmosphere.

Pull Factors	Responses	
	No.	%
Potential for employment	43	56%
Better service provision	22	29%
A safer atmosphere	34	44%
Low crime rates	42	55%
Fertile land	0	0%
Good food suppliers	2	3%
Less risk of natural hazards	6	8%
Greater wealth or affluence	20	26%
Political security	35	45%
A more attractive climate	5	6%
A more attractable quality of life.	42	55%
Other (please specify)	6	8%

Table 6: Pull Factors

Other responses included:

- Prospects for promotion;
- Close to family;
- Non-discrimination; and
- Effective educational system and public service, value for money.

Question 14. What would be the solution to eliminate “Brain Drain” and the migration of skilled people from developing countries?

Various improvements are required at Government level. The first is to stop corruption, improve political stability, create jobs and get crime under control. Eliminate discrimination laws and ensure equality across all races. Government should then investigate in possible tax incentives for scarce resources in order to retain these skilled professionals in the country.

Organisations need to employ the correct people to carry out the job efficiently and ensure equal opportunity based on skill and ability. In order to retain the skilled professionals, the organizations need to provide these professionals with the salaries they deserve. This will ensure that they will feel appreciated and therefore work harder and stay longer in the organisation. Organisations also need to provide sufficient mentoring to Junior engineers and ensure the transfer of skills through a mentoring programme. People feel that they just a number and the moment they are treated as such and there’s no recognition, then they will leave and go where they are valued and where there is a better future for them, not only financially but also where they are looked after emotionally. Schools and Universities need to improve their education. They need to be strict on high schools subjects and ensure high pass rates.

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OUTSOURCING Versus IN-HOUSE

There has been an increase in the outsourcing of engineering services in the last decade. There are two categories of outsourcing. Outsourcing in terms of employing workers on contract and outsourcing of work to another company.

Question 15. If you had a choice, would you rather be a contract worker (outsource your services to companies as a specialist) or be a permanent employee?

As shown in Figure 20, 70% of the respondents preferred to be permanent Employees, while 30% preferred to work as a contractor.

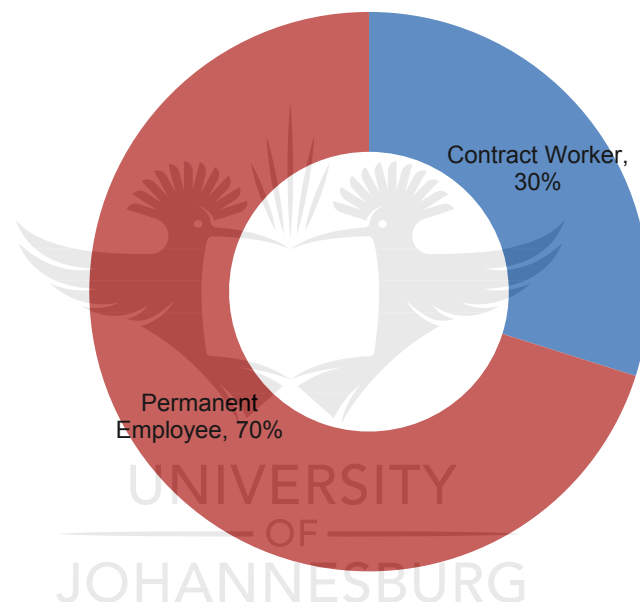


Figure 20: Contract worker versus permanent employee.

Question 16. Please provide a brief reason for your answer above.

The majority of the responses received from respondent's preferred permanent employment compared to contract work because of job security and a fixed stable income with benefits, e.g. Pension Fund and Medical Aid. While 30% of the respondents that preferred to work on contract felt that, it allowed them to be flexible with time and some were also exposed to different types of projects.

Question 17. Some large organisations prefer to outsource some of its works to other smaller companies. What could be the main reason for this?

This was an open-ended question and encouraged respondents to provide their views on this matter through experience. The majority of the respondents felt that it was cheaper and more cost effective for the organisation to outsource work since the overheads for smaller companies were less compared to larger organisation. Also, smaller companies tend to specialise in certain engineering fields and this is also more cost effective for the larger organisation.

The second highest responses received related to resources. In large organisations, the lack of resources and in some cases the lack of skilled resources, result in companies outsourcing work. Some respondent also felt that outsourcing of certain engineering activities is linked to Government and politics. Government has prioritised entrepreneurship and the advancement of Small, Medium and Micro-sized Enterprises (SMME) as the catalyst to achieving economic growth and development. This results in many large organisation outsourcing or providing work to the small to medium enterprises. In addition, skills development is enhanced through Black Empowerment, (BBBEE) and the Skills Development Act (1998).

A very small number of respondent felt that risk associated with engineering projects was the reason. By outsourcing of work, risk is also spreads and transferred to the smaller companies. This also eliminates the need of larger organisations to employ and then retrench people especially on medium term projects.

Question 18. There are various environmental reasons why employees stay at a company. What are your reasons for staying at your current company?

Respondents could choose from the following choices:

- I wouldn't want to rebuild most of the benefits that I have now if I left the company
- I have family responsibility
- I have good friends here at work.
- The company has been good to me and I do not believe in jumping from company to company.
- I am working to make ends meet and I do not want to take the risks in a new job.
- I would not like to the look for a job on the outside.
- I'm a little too old for starting over again
- I would not like to start all over learning the policies of a new company.
- I like to live in this area
- It is difficult to find a job.

As illustrated in Figure 21, the main reason for respondents staying at their current company is that the company has been good to them and the respondents did not believe in jumping (44%). 36% of the respondents found it difficult in finding a job while 31% have family responsibilities. 4% of the respondents would not like to look for a job on the outside and 6% would not like to start all over by learning policies at a new company. Other reasons (12%) by respondents included gaining valuable work experience, excellent exposure to projects and job satisfaction.

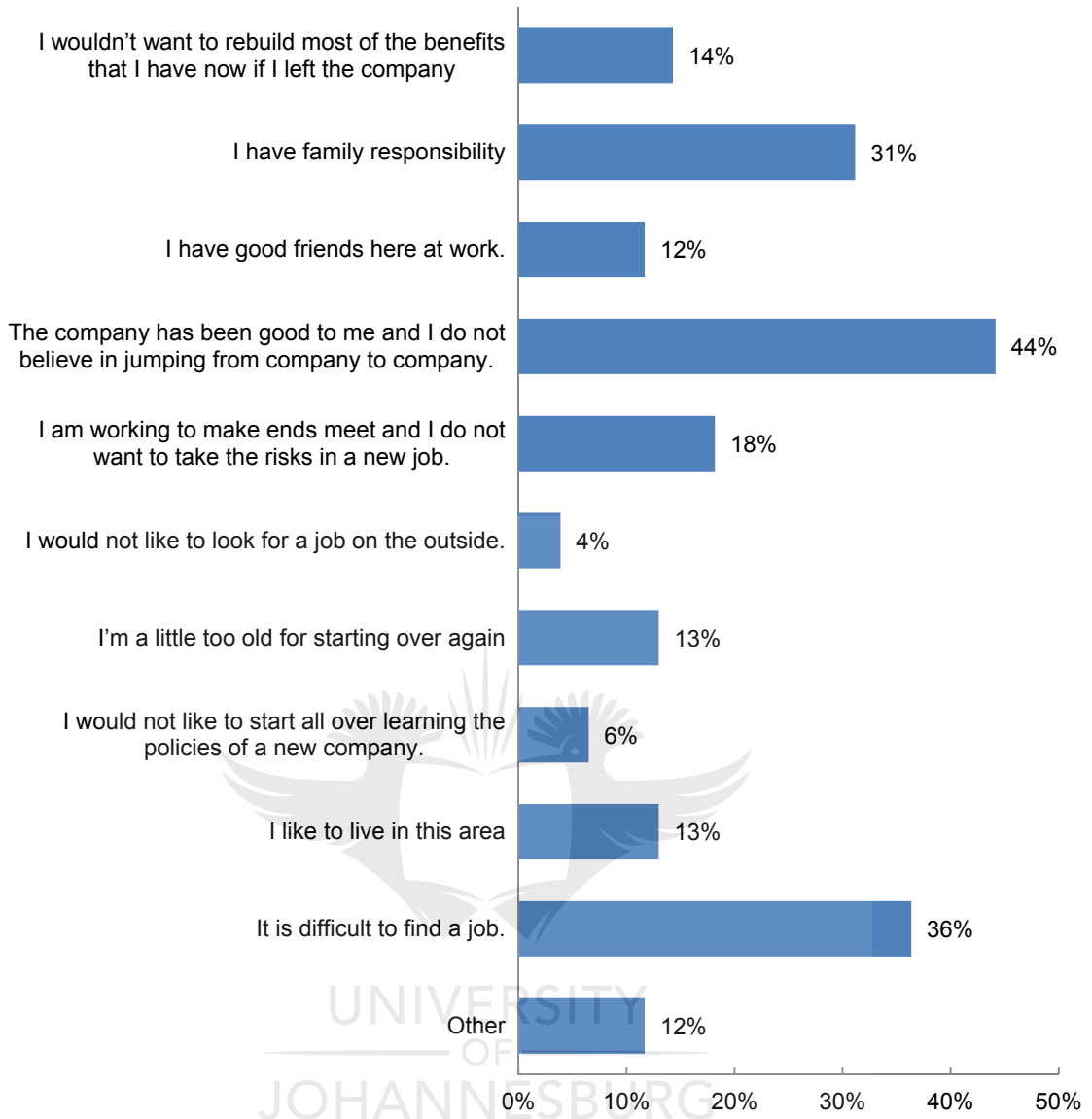


Figure 21: Environmental reasons for staying at your current company.

Leadership

Leadership is the activity of leading a group of people or an organization or the ability to do this. Leadership involves:

- Establishing a clear vision;
- Sharing that vision with others so that they will follow willingly;
- Providing the information, knowledge and methods to realize that vision; and
- Coordinating and balancing the conflicting interests of all members and stakeholders.

Question 19. Do you agree with the following statement “Leadership can be learnt”?

As shown in Figure 22, 71% of the respondents agreed with the statement ‘Leadership can be learnt’, while 29% disagreed.

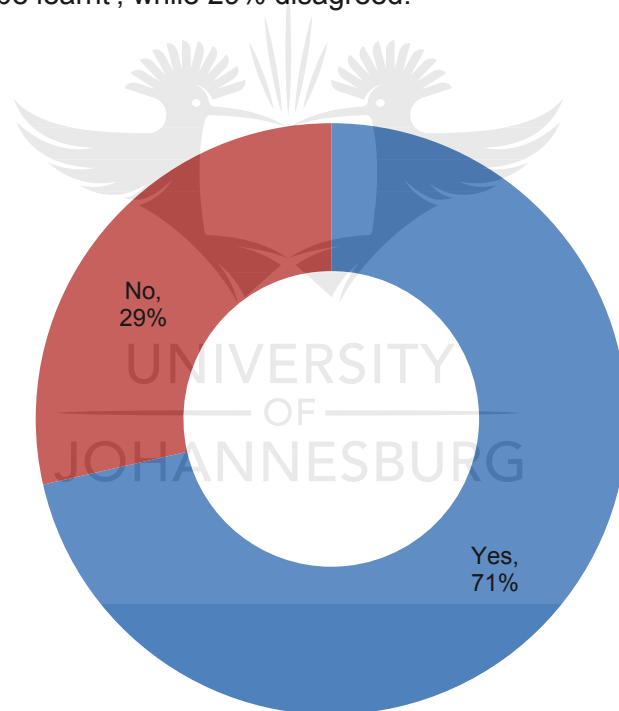


Figure 22: Can Leadership be learnt?

Question 20. If you answered yes above, should leadership courses be offered at undergraduate level to assist engineers for the future?

As illustrated in Figure 23, 95% of the respondents agreed that leadership courses be offered at Undergraduate level while 5% were not in favour of having leadership courses offered at Undergraduate level. Comparing the research results to 'Dean's Task Force on engineering Leadership Education Final Report' [42], leadership education is a solution to empower Engineers.

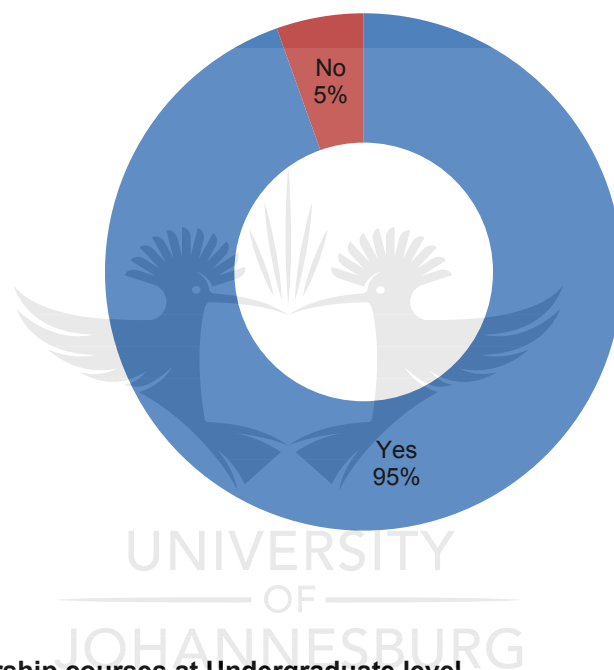


Figure 23: Leadership courses at Undergraduate level

Question 21. Similarities exist between a manager and a leader. However, there are also differences between the two. What differentiates a leader from a manager? Select those characteristics below that are applicable for a leader but not a manager.

The following characteristics were available:

- Influential
- Integrity
- Interpersonal Skills
- Develops trust and Respect
- Prioritizes

-
- Team Player
 - Builds consensus and
 - Continuously improves
 - Empowers others
 - Attracts Followers
 - Emotional Intelligence
 - Build Teamwork
 - Good Timing
 - Takes calculated risks
 - Helps others advance
 - Develops Other leaders
 - Makes Sacrifices
 - Visionary
 - Acts on Intuition
 - Build Strong Relationships
 - Leaves a Legacy

As depicted in Figure 24, 66% of respondents indicated Leaders empower others compared to a Manager and 64% responded that Leaders develop other Leaders. Other characteristics that differentiate a Leader from a Manager were Leaders develop trust and respect (55%); Leaders have emotional intelligence (51%), and visionary (51%). Leaders have interpersonal skills (48%) and help others advance (47%). Respondents also felt that leaders are influential (42%), attracts followers (42%), leaves a legacy (42%), are team players (40%), have integrity (39%), able to build strong relationships (38%), and build team work (36%). On the lower end of responses, some respondents felt that Leaders had good timing (6%), they prioritizes (9%), act on intuition (12%), take calculated risks (17%) builds consensus (19%), continuously improves (23%) and makes sacrifices (23%)

In the case of other responses, respondents indicated that leaders need excellent technical skills and a leader earns trust and respect not by developing it. A leader pulls from the front and pushes from the back whilst walking alongside.

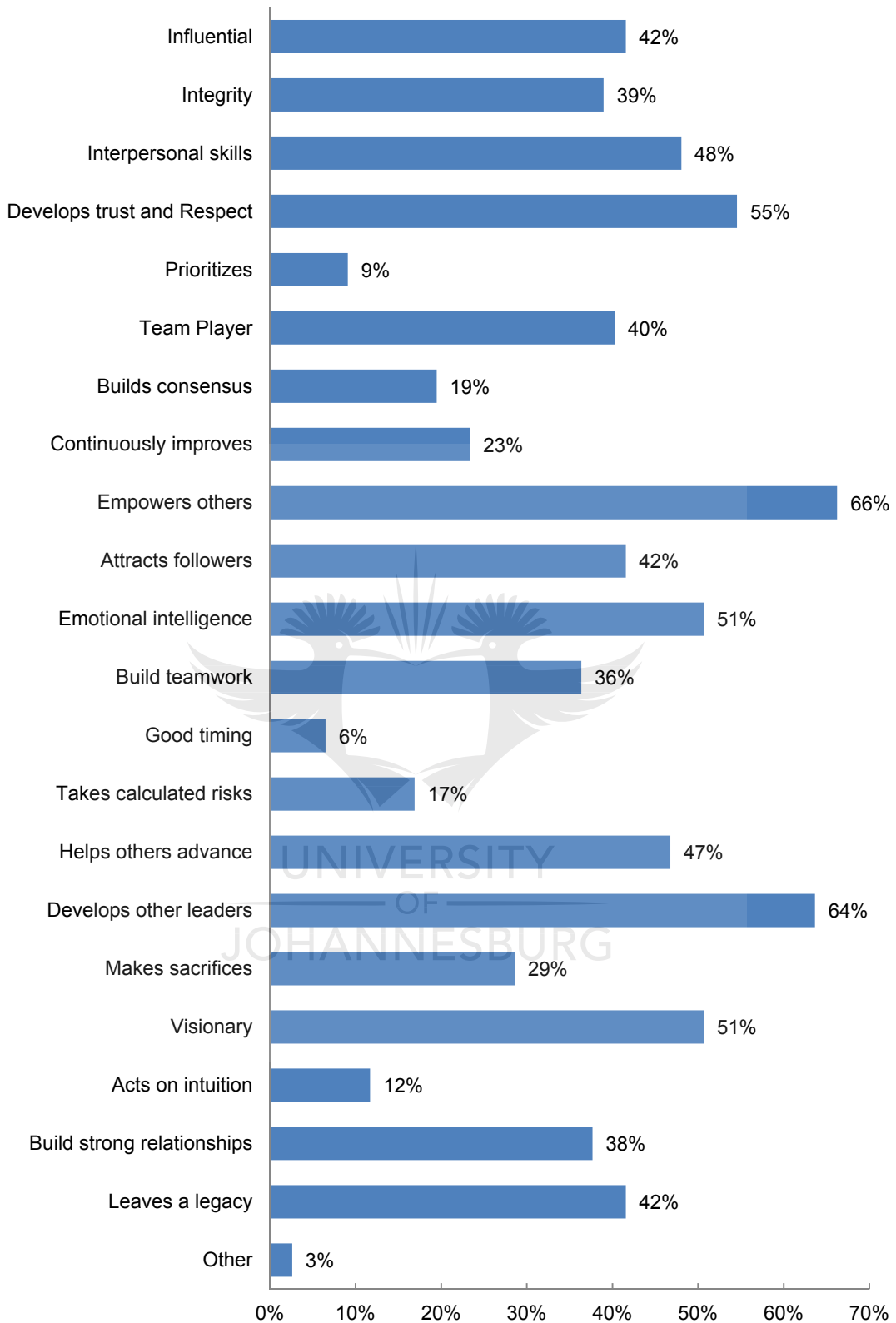


Figure 24: Characteristics applicable for a leader but not a manager.

Human Resource Management

Project human resource management refers to how a Project Manager runs a project team. One needs to understand what resources are required to enable successful completion of a project. After that, it is all about managing the people on the team including giving them extra skills to do their jobs.

Question 22. Choose any 3 of the following major resource challenges when dealing with projects:

- Resource capacity planning is poor;
- Resource risks are not assessed;
- Not enough appropriately skilled resources;
- Resource use is not optimized;
- Schedules/deadlines are unrealistic;
- Resources are assigned inconsistently;
- Too many unplanned requests for resources;
- Resource utilization is poorly documented;
- Shifting resources to respond to problems; and
- Transition process for resources is inadequate.

Figure 25 illustrates the summary of the results. 45% of the respondents indicated that the schedules/deadlines are unrealistic when dealing with projects while 43% indicated that not having enough appropriately skilled resources was a challenge and the third major challenge when dealing with projects is poor resource capacity planning (39%). Further, challenges identified by respondents when dealing with projects were shifting of resources to respond to problems (35%), too many unplanned requests for resources (26%), use of resource is not optimised (25%), and resource risks are not assessed (23%). The least of the challenges were resources are assigned inconsistently (9%) and transition process for resources is adequate (9%). Other challenges highlighted by respondents were uncertainty with the start date of projects, poor support staff, lack of competent engineers and insufficient budgets to allow sufficient time for skilled individuals.

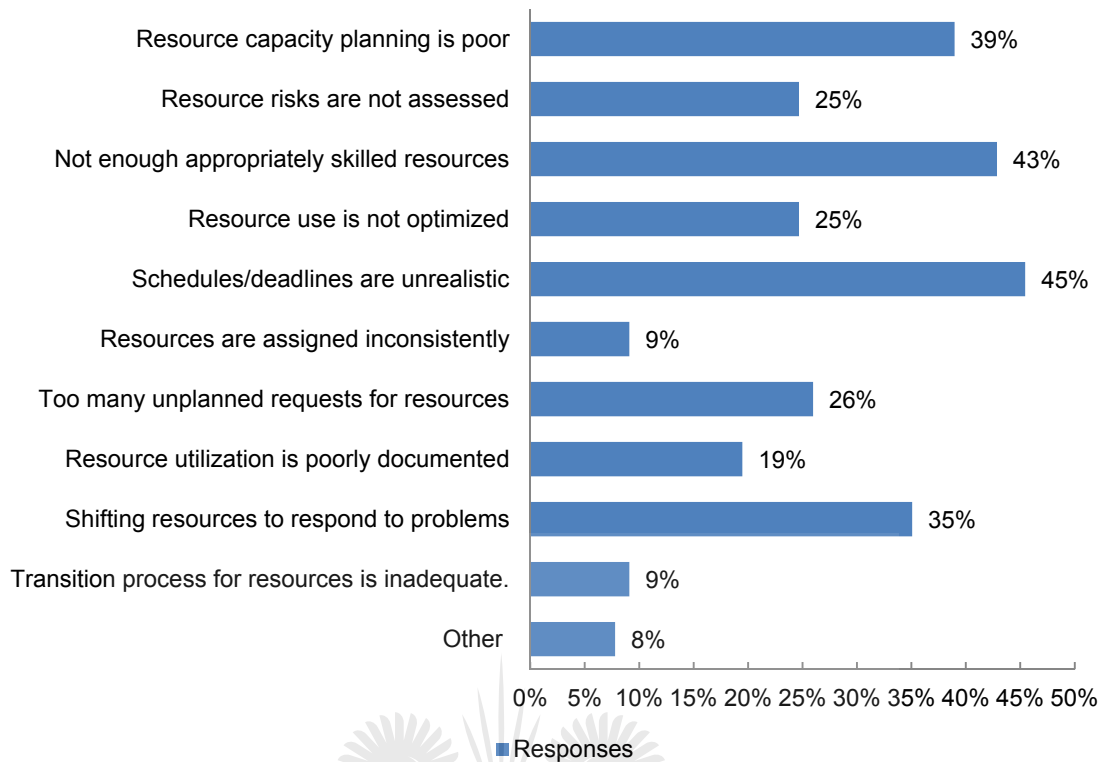


Figure 25: Major resource challenges when dealing with projects

Question 23. Small things' matters the most in an organizational environment, In terms of recognition, which one of the following would be seen as the most preferred means of recognition:

- Financial rewards;
- Gifts;
- Acknowledgement; and
- Other

As shown in Figure 26, 51% of the respondents preferred acknowledgement, while 47% preferred financial rewards. Other responses received indicated that it depends on the individual. An insecure individual would possibly prefer acknowledgement while a self-confident person may require a financial reward. Another respondent indicated that considering an individual receives a salary monthly, this is considered to be a financial reward and therefore acknowledgement would be more appropriate. One respondent felt that employees needed to be listened, especially with concerns and queries that are raised by an individual.

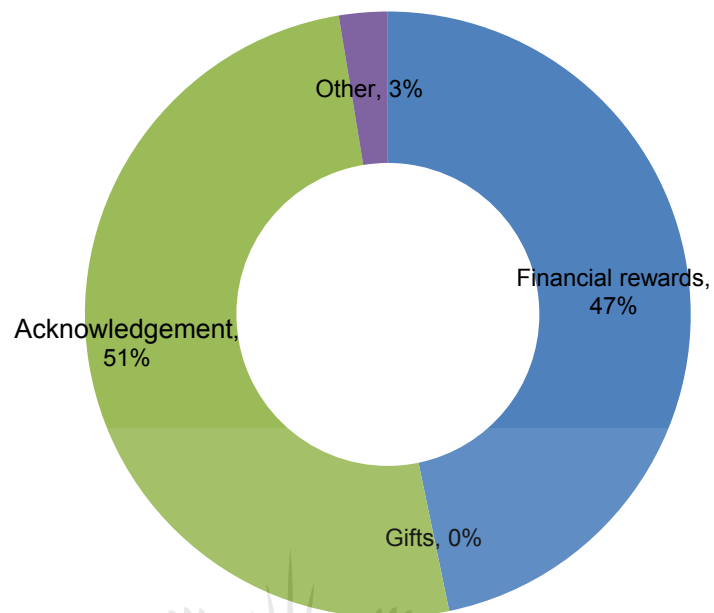


Figure 26: Most preferred means of recognition

Skills Management

Question 24. How many projects are you concurrently working on?

As depicted in Figure 27, 23% of the respondents were working on four projects concurrently; followed by 18% that were working on 6-10 projects and 17% of the respondents were working on 3 projects. Only 1% currently has no projects to work on. While 4% of the respondents were currently working on between 30-40 projects, this is the largest number of projects. However it is noted, that all projects vary in size.

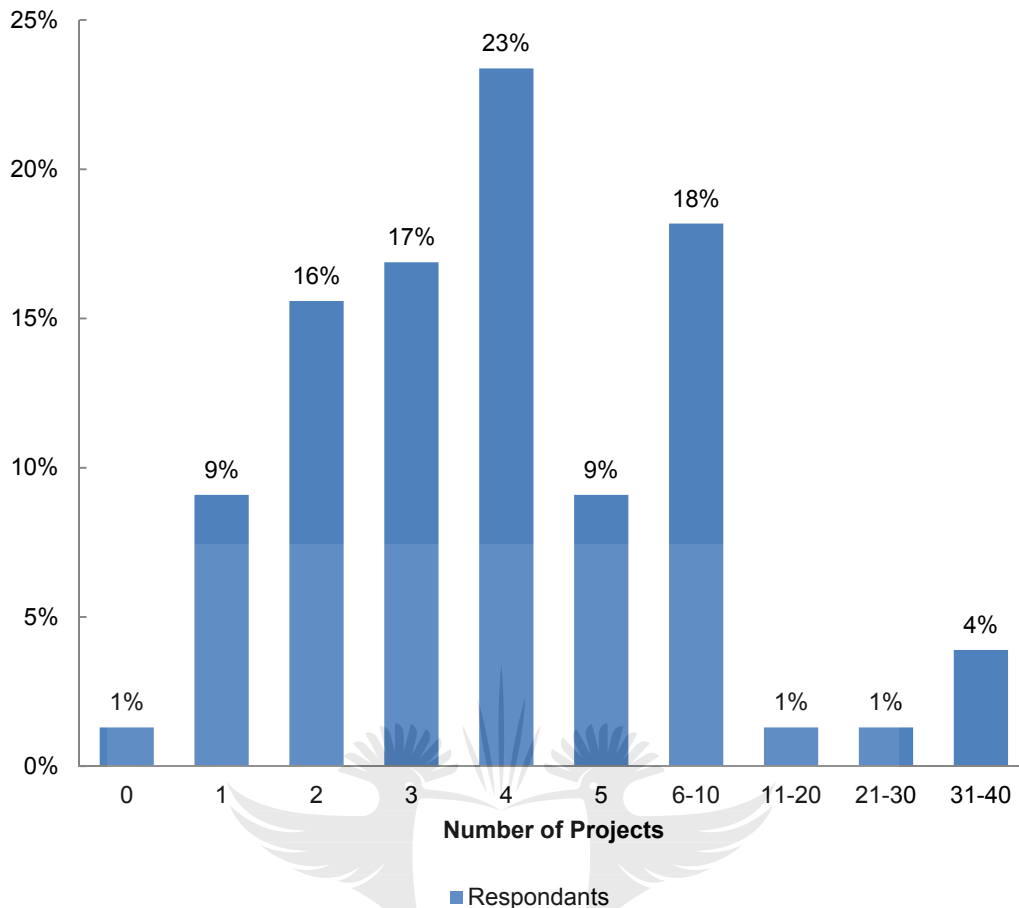


Figure 27: Number of Projects respondents are concurrently working on

The data was further analyzed, as shown in Figure 28, to obtain an indication of the number of projects respondents were simultaneously working on based on their years of experience. 6% of the respondents that had 6 to 10 years of experience were working on 4 projects while another 6% with the same years of experience, were working on 2 projects concurrently. It was also noted that 5% of respondents with 16 to 20 years of experience were working on 4 projects, while another 5% that have 21 to 30 years of experience were also working 4 projects. Only 3% of the respondents with 1 to 5 years of experience were working on 4 projects. 1% of the respondents with more 30 years on experience were working on no projects. Respondents that were working on 31 to 40 projects had 21 to 30 years of experience (3%) while 1% of the respondents with 11 to 15 years of experience were also working on the same number of numbers.

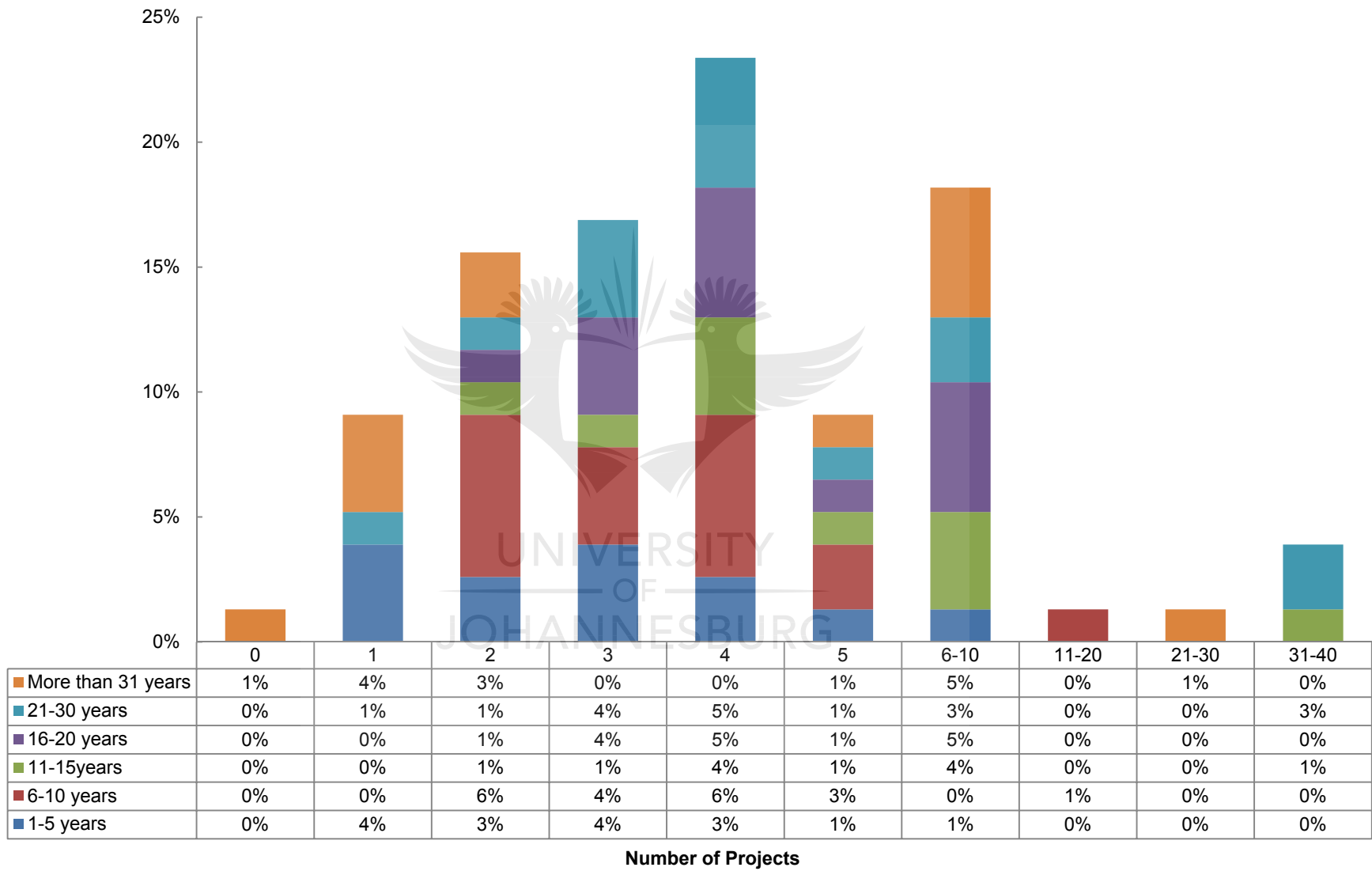


Figure 28: Number of projects based on years of experience.

Question 25. What are some of the challenges that you have experienced or are experiencing when working on multiple projects concurrently?

This question was an opened-ended question. Answers from respondents have been consolidated. There were various challenges highlighted by respondents for working on multiple projects simultaneously. These are reported briefly below.

Time management and the planning of task were identified as one of the critical challenges experienced by respondents. Poor planning in some instances results in the resource waiting for information from others and this may also affect the project deadline. When information provided to a resource is late, this affects the individual resource and in some instances other team members working late or overtime in order to meet the deadline.

Another challenge is working on different projects for different clients. This also affects the deliverable of a project. Every client's expectation is different; therefore one needs to understand their clients' requirements. Unexpected demands may affect the quality of deliverable to the client and in some instances they may be errors in the engineering output.

Resources also are a challenge. Resources are either poorly planned on a project or over allocated on a project. This is due to the lack of resources. This may also result with senior engineers/personnel leaving junior engineers to their own devices with minimum support or mentoring. The result is re-work by the junior or senior or another resource not initially allocated to the project. Consequently, this costs time and money to the Company.

Poor communication or the lack of it by team members is also a challenge to some respondents. The change in scope is also a challenge in some instances. A rather positive response by a respondent indicated that working on multiple projects meant more learning opportunities. Conventional wisdom supported but the literature suggests that employees should be multi-skilled to meet the demands of globalization in a knowledge based economy.

Question 26. Within business and Knowledge Management, two types of knowledge are usually defined, namely explicit and tacit knowledge. The former refers to codified

knowledge, such as that found in documents, while the latter refers to non-codified and often personal/experience-based knowledge. In engineering which of the following knowledge are most suited to an engineering organisation:

Respondents could choose anyone of the following:

- Explicit;
- Tacit; and
- Balance of the two.

As depicted in Figure 29, 83% of the respondents indicated that a balance between explicit and tacit knowledge is required, while 9% of the respondents felt that explicit knowledge was most suited. Only 8% mentioned that tacit knowledge was most suited to an engineering organization.

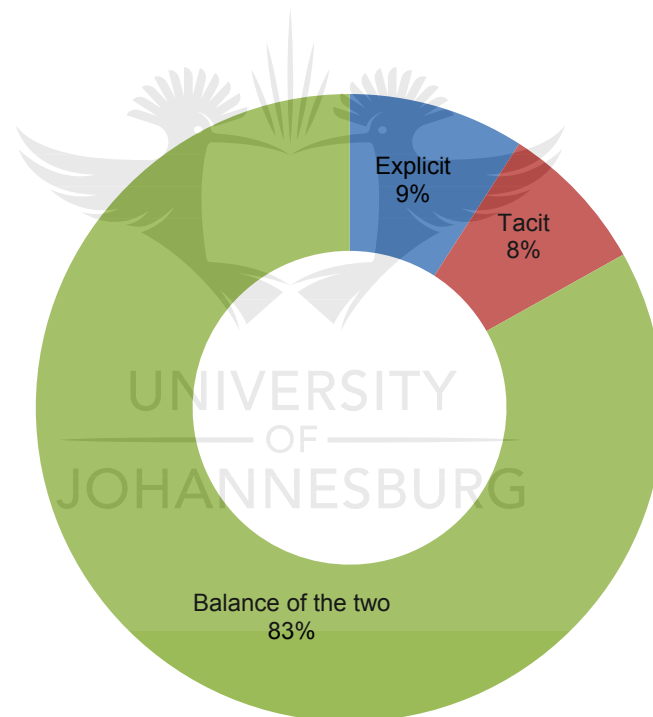


Figure 29: Knowledge Types

Question 27. Please provide a reason for your answer to question 26?

Considering that majority of the respondents chose a 'balance of the two' knowledge types, this will be discussed first. In engineering, one requires a balance between experience and expertise. Experience is tacit while expertise is explicit. The foundation of engineering expertise is in knowing the relevant codes of practice and guidelines. However, the nature of the engineering problem makes each project unique, resulting in the need to keep the knowledge acquired from experience as the application of the acquired knowledge is project specific.

Considering that every project is different, an engineer will not know the application by reading a book or a guideline. Experience helps to solve problems. The theoretical knowledge helps to understand the problem, but often the practical experience helps provide the optimum solution based on previous lessons learnt. With experience, it becomes easier to solve problems. For an engineer to come up with innovative ways of doing things, it has to be done many times before and ways identified that should work. This will enable them to finish a certain project faster and at a lower cost. An engineer will need knowledge from specifications and codes to ensure that everything is done accordingly and those always change so you need to constantly learn in acquiring new skills and always study certain documents.

Experienced engineers are those that mastered explicit knowledge and operate in the tacit environment. In simple engineering balance: Theoretical + experience = professional. Respondents that chose Explicit felt that all designs carried out are in accordance with codes and standards applicable to the engineering sector, as they have access to a full range of explicit knowledge in order to do the job, especially when formulas are required.

On the other hand, those respondents that felt tacit or experience was most important, argued that experience cannot be found in documents but is built on involvement with multiple projects over time. There are engineers that often have gained enough knowledge through experience that this is not documented in textbooks or documentation. Theoretical knowledge may be found in documents or text books, but often is not understood by the reader.

Question 28. What do you consider to be the 3 most essential skills and attributes of an engineer?

Respondents could choose a maximum of 3 of the following choices:

- Technical knowledge and skills, practical ability e.g. use of modern technology;
- Intellectual skills, ability to learn and understand new information;
- Attitudes, behaviour, thoughts and actions;
- Standards of engineering practice; awareness and observance of engineering codes of practice and ethics; understanding of the role of an engineer; and general knowledge of the working legislation and regulations;
- Business practices: understanding of economic and financial issues, and ability to work within a business- orientated environment;
- International/national history and culture: understanding of other cultures and customs; and
- Proficiency in languages, understanding other languages and familiarity with technical languages.



As depicted in Figure 30, 75% of the respondents indicated that the most essential skill of an engineer is to have technical knowledge and skills, this was followed by 73% of the respondents that rated standards of engineering practice to be an essential skill. The third most essential skill selected by 68% of the respondents was Intellectual skills. 40% of the respondents indicated business practice was an essential skill and attribute while 31% rated attitudes to be of importance. International/national history and culture (4%) and proficiency in language (8%) are perceived to be the least essential skill and attributes of an Engineer.

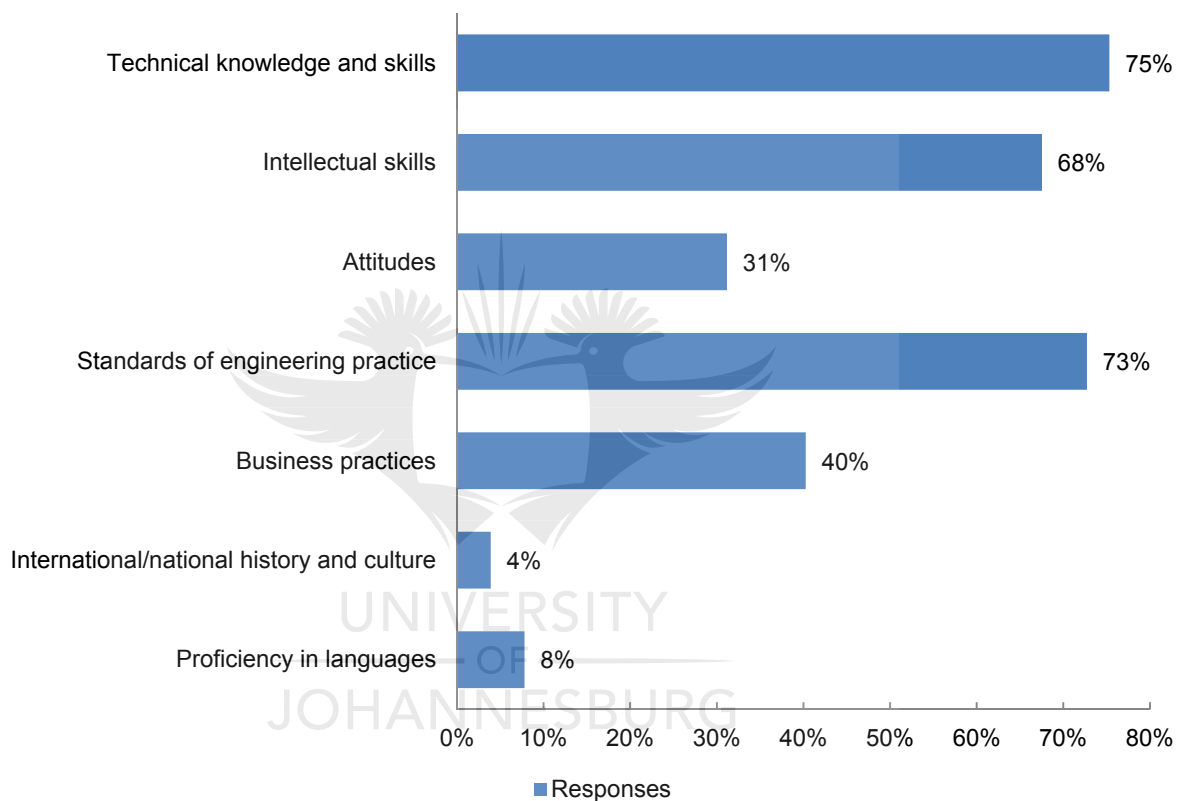


Figure 30: Percentage of Skills and Attributes based on all Respondents

Therefore based on the responses, the 3 most essential skill and attribute of an engineer, according to the respondents are:

- Technical knowledge and skills (75%)
- Standards of engineering practice (73%); and
- Intellectual skills (68%)

Comparing these survey results with Nguyen’s research [54] results on the industry group, it reflects a close trend on some of the essential skill and attributes of an Engineer. The comparison between the survey results and Nguyen’s research [54] (for the industry responses) is shown in Figure 31.

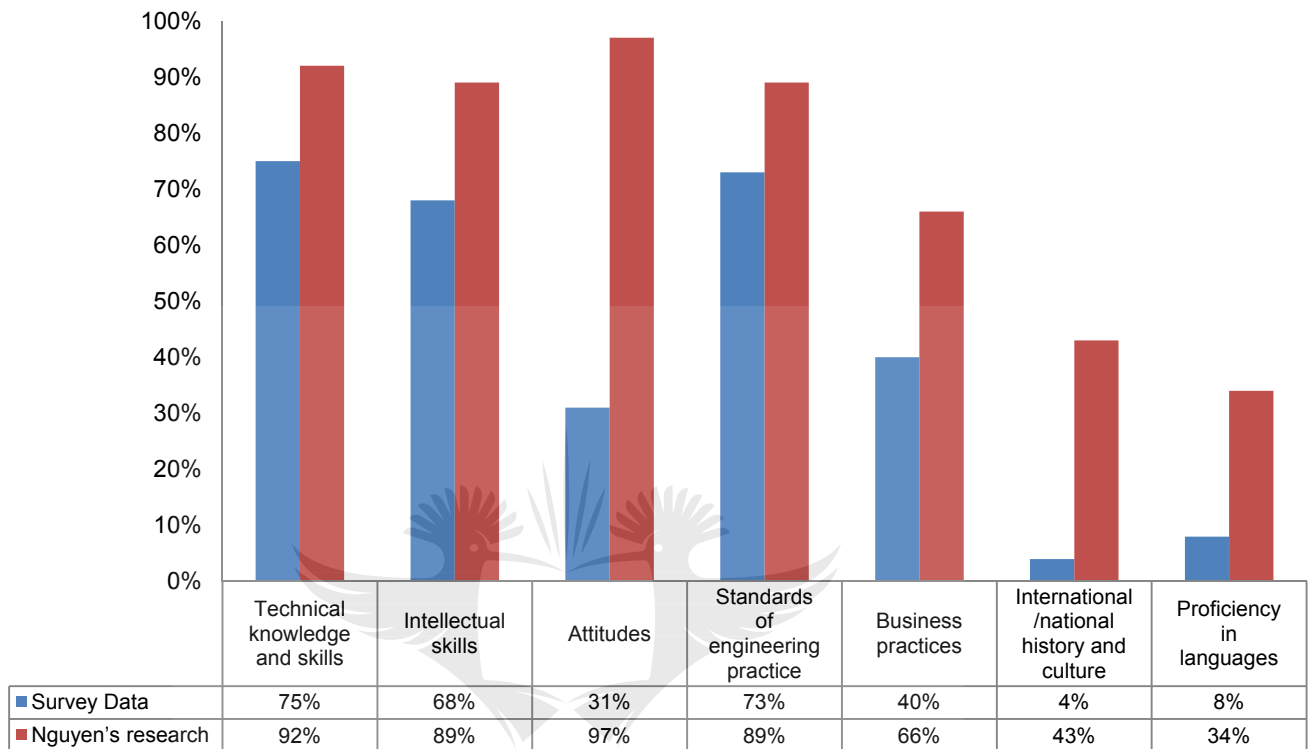


Figure 31: Comparison between the survey results and Nguyen’s research

Question 29. A projects success is based on various aspects. Choose 5 factors that have the highest impact on projects’ success. Respondents had a choice of the following selection and could choose a maximum of 5 factors applicable to their experience:

- Compliance with the planned budget, time frame and performance criteria;
- Clearly defined goals and directions;
- Accurate schedule and plan;
- Timely and comprehensive control;
- Adequate use of project management techniques;
- Adequate use of technical skills;
- Competent project team members;
- Clearly defined roles and responsibilities;
- Synergy of the team;
- Experience and expertise of the project manager;

-
- Adequate risk management;
 - Ability to handle unexpected problems;
 - Communication and consultation with stakeholders;
 - Provision of timely data to key players;
 - Client acceptance of the results;
 - Stakeholders satisfaction;
 - Owner involvement within the project;
 - Sponsor involvement within the project; and
 - Top management support.

As mentioned before, respondents were asked to choose from the list of factors presented above, and to select 5 factors that had the highest impact on a projects' success. Since all these factors are relevant to a projects' success, each factor received a varied response. However, certain factors were selected more than other factors. Thereby, it is deduced that the factors that were chosen by most of the respondents have higher impacts on a projects' success than the others. As depicted in Figure 32, the 5 factors with the highest impact on a projects' success are compliance with the planned budget, time frame and performance criteria (57%); competent project team members (53%); clearly defined goals and directions (49%); clearly defined roles and responsibilities (42%); and communication and consultation with stakeholders (32%). Sponsor's involvement within the project (6%), and top management support (9%) had the least impact on projects' success, since they received the least responses. Some other factors that respondents felt had an impact were adequate risk management (31%), client acceptance of the results (30%); synergy of the team (23%); ability to handle unexpected problems (23%); and adequate use of technical skills (22%).

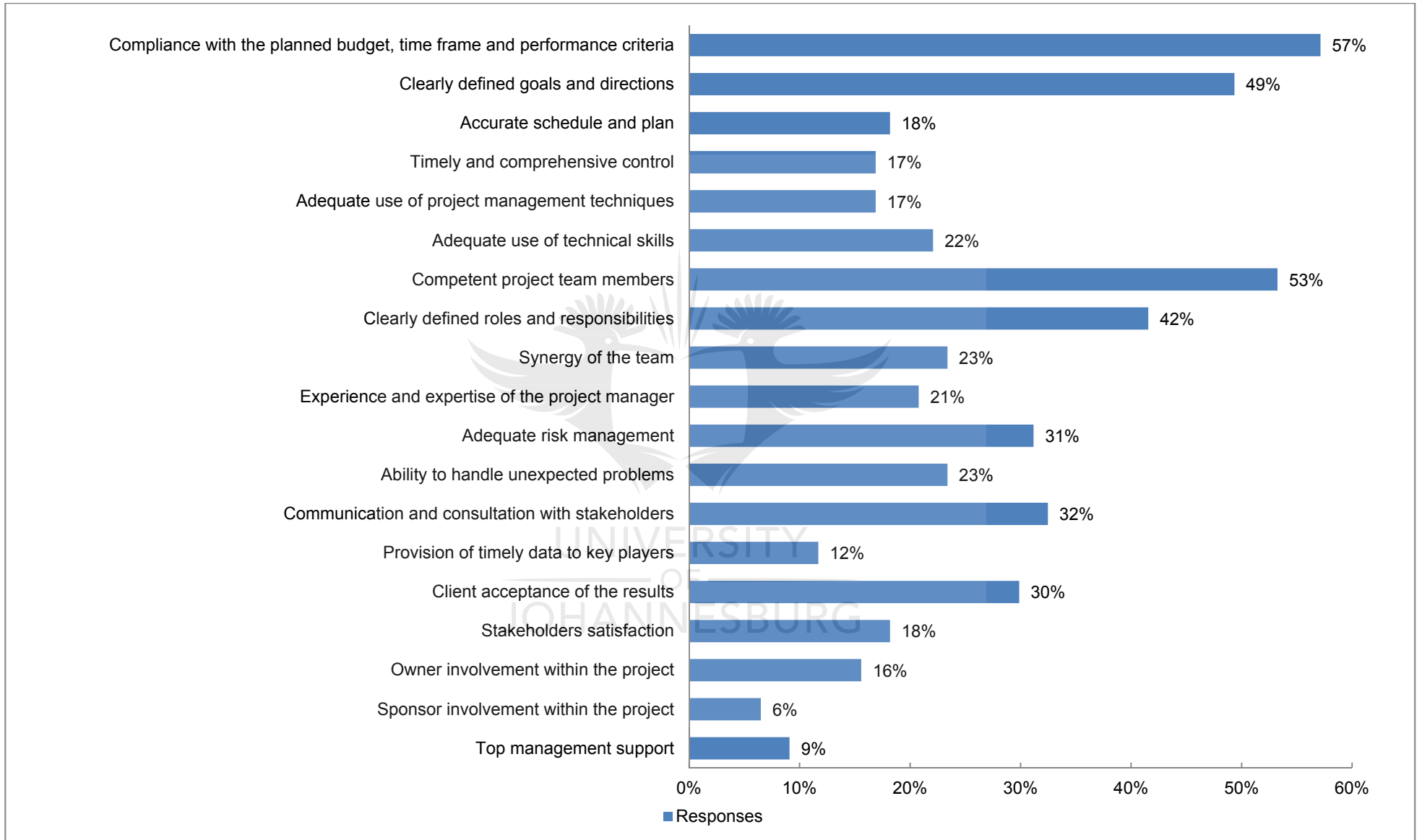


Figure 32: Factors that have the highest Impact on Projects' Success

4.4 Limitations to the Study

Although this research was carefully prepared, there were some unavoidable limitations. Firstly, due to the unforeseen circumstances experienced at the company where the survey was conducted, this affected the time to obtain responses from the entire target population. The target population was given a week but this was further extended due to the low response rate in the first week. Therefore, to generalise the results for a large organisation, the study should have involved more organisations. Secondly, work commitment by the target population may have also affected the responses received because some responses received were incomplete and was discarded.

4.5 Summary

The survey was conducted at a large South African owned Consulting engineering organisation with approximately 700 employees, with only 77 responses received. The survey question included both qualitative and quantitative responses. Responses received for all the age categories with varied years of experiences. Responses were received from Gauteng, Western Cape, Eastern Cape and KwaZulu-Natal.

The survey results can be viewed favourably as the responses received corresponded closely to the literature review. The data obtained has given valuable insight on the challenges experienced with resources on projects. The lack of resources is still concern as depicted in the survey. Other major concerns are the lack of planning and change. Having the correct skills is of great important on any project. However these skills are lost especially when professionals leave the country. This trend is persistent. The country's political situation has a huge impact on Engineers and the engineering Sector and is one of the main reasons for the Brain Drain as emphasized in the literature review. To eliminate the Brain Drain, improvement is needed at government level.

Engineers stayed at their current organisation because the company has been good to them. Having great leadership is one of the many factors to ensure the success of a project, therefore future Engineers need to be empowered through leadership courses. Engineers need acknowledgement in order to be more effective. Therefore employee acknowledgement is a great way keep workers engaged and is essential

for a project to succeed. A combination of skills is required by an Engineer to ensure a project succeeds.

Compliance with the planned budget; time-frames and performance criteria is critical to ensure the success of a project.

In order to ensure a projects success, the following top 5 features need to be considered on projects:

- Compliance with the planned budget, time frame and performance criteria;
- Clearly defined goals and directions;
- Competent project team members;
- Clearly defined roles and responsibilities; and
- Communication and consultation with stakeholders.



CHAPTER 5: CONCLUSION AND RECOMMENDATION

5.1 Introduction

The objective of the study was to understand the challenges experienced on engineering projects because of limited resources (in this case, engineers). The aim was to assess the problem in South Africa and develop a suitable strategy and action to manage this challenge of limited Engineering resources.

5.2 Conclusions

In analysing the results, the following conclusions were drawn:

The greatest challenges experienced with projects are the lack of planning, change requirements and specification, followed by the lack of resources. Both planning and change requirements are reliant on resources. Planning refers to how and when tasks are carried out by resource. Any change requirement will affect the resources working to the project.

The project schedule was identified as one of the greatest causes for a project to fail. Failure to keep to the schedule of the project affects the project cost and increases the use of resources, thereby affecting the allocation of the same resources on other projects. Change was considered to be the next major challenge. Change to a project will have a negative result on the cost and the schedule. Again, Change will, in most cases result in the additional use of resources. The other factor that also posed a problem was planning. Inadequate planning results in the use of incorrect resources. Lack of Skills and Brain Drain were the two main reasons for the lack of resources in engineering projects.

5.2.1 Lack of Skills

Apart from having the relevant qualification, Engineers need to display evidence that they possess other skills. When selecting teams, too much focus is given in selecting an engineer or resource with technical skills and other skills are often overlooked. Engineers are problem solvers and therefore they need to have problem solving skills. Also, engineering projects are not carried out in isolation, as there is a need to interact and co-ordinate with other disciplines (whether it is engineering or non-

engineering). Therefore, interpersonal skills together with organisational skills underpin an important proficiency that is required by an engineer.

The lack of skills is predominantly due to professional leaving the industry and in some instances leaving the country. This results in a skills gap. South Africa's educational system is in a crisis. South Africa has the worst educational system of all the middle-income Countries [58]. There is no improvement in maths and literacy. Moreover, these two subjects are the basic requirements to study engineering. Engineering salaries are low due to the lack of engineering projects and Governments investment and implementation of infrastructure is inadequate. This results in a lower demand for skilled engineers.

5.2.2 Brain Drain

Political instability is the foremost cause for brain drain. Political instability leads to economic recession and with recession; the implementation of infrastructure requirements by a nation is limited due to funding from Government. Others factors also contribute to the limitation of infrastructure by government. These include but are not limited to corruption, project delays and strikes.

With the lack in implementing infrastructure, engineering jobs are scarce and thereby resulting in lower salaries. Therefore, engineers often take their skills abroad where there is a demand for the engineering profession. As much a BBBEE may hold a positive outcome for the Black people of South Africa, it has a negative impact on the White South Africans. Skilled White South Africans therefore leave the country which also results in a loss of skills transfer and skilled human capital.

5.2.3 Project Success Factors

Outsourcing of work is dependent on the organisation and its projects. Organisations tend to outsource work based on a special skill that may not be available within the organisation. These impacts on skills transfer. Also in some cases, outsourcing of work may be cost effect to the project and organisation because of the overhead cost of the larger organisation.

Permanent employees stay at their current companies due to job security, income stability and in rare instances job satisfaction. Contractors on the other hand have the freedom and flexibility to work as and when they desire. Ultimately a large organisations needs to ensure service delivery, client satisfaction and low project costs. The resource carrying out the work is irrelevant to the large organization. Leaders are preferred compared to managers because leaders create goals, vision and stimulate the team's innovation. Leaders are visionary and empower others.

Suitable and correct resources are required for any project to succeed. The lack of resource planning and unrealistic deadlines causes additional pressure on resources, resulting in a failed project or task. A lack of skilled resources is also a challenge because the incorrectly skilled resource used on the project may not meet the deadline or the client's requirements. Another challenge with resourcing is moving resourcing around to either assist others or carry out damage control.

In engineering, a balance is required between experience and expertise. Engineers need to understand guidelines, processes, standards and the application thereof. There is a need to ensure professional development because engineers are required to have technical knowledge and skills, understand standards of engineering practice and have intellectual skills.

Project success is dependent on various factors. Teams need to abide by the project plan, planned budget, timeframe and performance criteria. Goals need to be clearly defined upfront. Project team member have to be competent in their field of expertise. Roles and responsibility to be clearly defined and understood by all team members and ensure proper communication and consultation with stakeholders. Success factors of a project will determine the positive outcomes of any projects. The environment of a project is always dynamic, so success factors might change over

time. Success is desired in our lives every day, in both business activities and in projects.

5.3 Recommendations

In order to achieve the project success, improvements are required from various sectors but the most important one is at Government level. Government needs to invest in infrastructure requirements. In order to improve the economic state of the country, harsher laws need to be effected to eradicate crime and corruption. This will attract foreign investment into the country and more people being attracted to the country, thus resulting in skilled people leaving the country. This will also create an opportunity for more jobs and reduce the unemployment rate.

Considering that the problems at Government level will not change overnight, government factors also affect Consulting companies. However, Companies need to invest and understand their employees by providing sufficient training and acknowledging their employees in order to retain these human assets. Companies should ensure that training programmes should be in place. Companies should also show more care towards their employees to ensure job satisfaction. Project Managers are to improve on the planning of projects to ensure project success.

At Universities, leadership's courses should be included in the curriculum. Universities should be on top of the current trends and ensure that the curriculum meets technology advancement as underpinned demand for knowledge workers *vis-à-vis* the knowledge based economy, globalisation and retaining skilled human capital.

5.4 Future Research

Further research can include a more in-depth analysis as to how other large organisations perceive a projects success and lack of resources. Further research can also include an analysis associated between small to medium engineering Consulting Companies and larger engineering Consultants Companies and the related challenges experienced with projects and resources.

Investigation are also required at Government level to determine what intervention government is planning to rectify the brain drain situation in the country and improve on the economy of the country. Further investigation is required on the BBBEE

regulations to ensure a reduction in the skilled minority leaving the country. Investigation and research is also required at Universities to ensure that adequate measures are in place to meet the technical advancement in engineering.



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APPENDIX A: Survey Questionnaire



Introduction & Prior Informed Consent

Researching the Challenges Facing Projects Due To A Lack Of Resources

- This is a research study into the challenges on projects due to the lack of resources.
- This research is done through a leading university and is in fulfilment of the requirements for an Engineering Master's Degree.
- This is a request for voluntary participation in this research by answering an on-line survey questionnaire.
- As your time is valuable we have optimized the questionnaire to be as short as possible, and you should be able to complete it in about 20 minutes or less.
- No company information will be asked for in the survey.
- All data will be kept secure and confidential.
- Ethical clearance was obtained for this research.
- Prior informed consent is requested from you taking the above into account.
- Should you wish to receive summary information once the research is completed this option will be given to you at the end of the questionnaire.
- Should you wish to contact us regarding this study you are free to do so.
- Information will be provided at the end of the questionnaire.

Your input to this research is highly regarded and we would like to express our sincere appreciation for your participation and time.

As a result of Globalization, one of the greatest challenges we face today is the delivery of basic services in order to meet an expanding population. Innovative engineering solutions is fundamental to address these challenges, Yet at this time when our need for engineering talent is huge, and when our young people are increasingly interested in how they can help to save the planet, we are failing to persuade them that engineering careers are exciting, well-paid and worthwhile.

Organisations rely on Projects to ensure the business needs are met. Projects rely on resources to ensure the project meets its goal. Therefore, projects rely on the effective employment of finite resources, whether these are people, equipment or facilities – in other words anything required to complete a project activity – and these will cost money. The organisation faces the challenge of ensuring that they make the most of these finite resources.

General Questions

Q1 What age category do you fall in?

- Early Adulthood (Ages 20-34):
- Midlife (Ages 35-50):
- Mature Adulthood (Ages 50-80):

Q2 What is your Job Title?

- Project Manager
- Assistant Project Manager
- Technical Lead
- Engineer
- Technologist
- Graduate Engineer
- Technician

Q3 How many years of experience do you have in your field of expertise?

- 0-5years
- 6-10years
- 11-15years
- 16-20 years
- 21-30 years
- More than 30years

Q4 Select your current work location.

- Eastern Cape
- Free State
- Gauteng
- KwaZulu-Natal
- Limpopo
- Mpumalanga
- Northern Cape
- North West



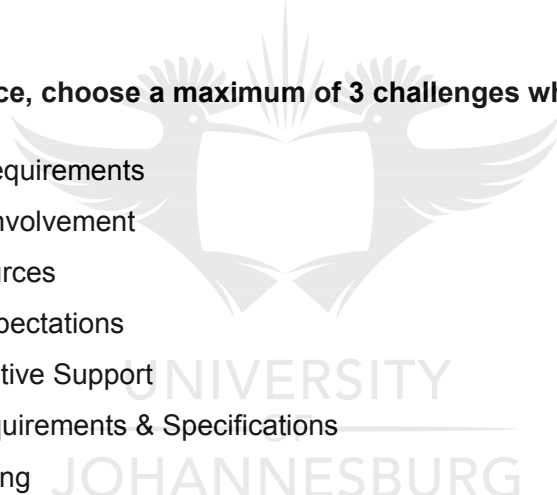
Q5 What are your Qualifications?

- Diploma in Engineering
- B.Tech in Engineering
- Degree in Engineering
- Masters in Engineering
- Other (please specify)

PROJECT FAILURE CHALLENGES

Every project is different and therefore there are several reasons why projects fail and every failed project will have its own set of issues and causes. Sometimes, it can be a single trigger that leads to failure, but often, it is a complex set of problems that combine and cumulatively result in failure.

Q6 In your experience, choose a maximum of 3 challenges when working on projects:

- 
- Incomplete Requirements
 - Lack of user involvement
 - Lack of Resources
 - Unrealistic Expectations
 - Lack of Executive Support
 - Changing Requirements & Specifications
 - Lack of Planning
 - Didn't Need it Any Longer
 - Lack of IT management
 - Technical Illiteracy
 - Other

Q7 Resources on projects are the common factor for projects to fail. In your experience, which one of the following holds the greatest challenge when it comes to resources?

- Change: Change in the scope may result in a lack of resources, as they may be needed on other projects. Change in the resources (needed on another project or resignation from the organisation) can affect the project.
- Scheduling: Failure to meet the project schedule can result in increased costs because of human resource downtime. The project team did not follow the schedule that was established
- Funding: results in failure due to inadequate funding for the correct resources.
- Resources: A project can fail due to the incorrect or insufficient resources used on the project.
- Incentives: Engineers/Resources feel that they are not motivated on successful completion of a task.
- Other (please specify)

Skills Shortage

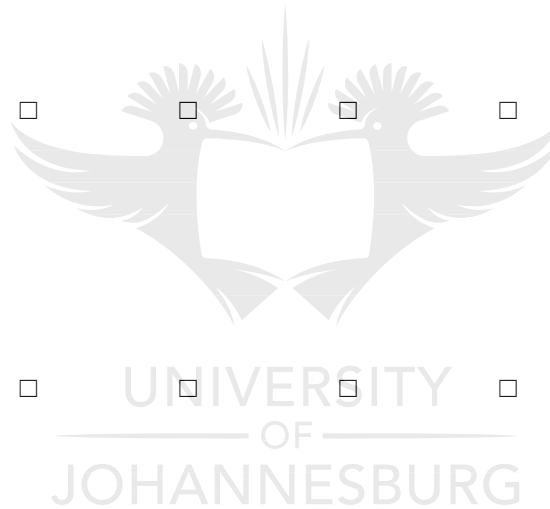
A skill shortage is when any one of the following situations arises or a combination of them:

- shortage of workers in a particular occupation,
- labour demand exceeds availability of skills, or workers
- lack appropriate qualifications

Q8 The heart of any project, and the true engine of its work, is its resources. That is why bringing together the right people is extremely important. Although the skills needed to accomplish the work should govern team selection, it is unlikely that you will get all the expertise you need without providing some training. Consider the following areas of proficiency. Provide a rating for each of the following:

APPENDIX A: Survey Questionnaire

	Not Important	Somewhat Important	Important	Very Important	Extremely Important	N/A
Technical skills in a specific discipline, such as market research, finance, or software programming	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Problem-solving skills enabling individuals to analyze difficult situations or impasses and to craft solutions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Interpersonal skills, particularly the ability to collaborate effectively with others—a critical aspect of team-based work	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Organizational skills, including networking, communicating well with other parts of the company, and navigating the political landscape, all of which help the team get things done and avoid conflicts with operating units and their personnel	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>



South Africa is presently experiencing a serious shortage of skilled workers. This situation is negatively affecting the economic prospects and global participation of the country. The failure of the national education and training system to supply the economy with much needed skills required to support economic growth and job creation. Various factors result in serious skills shortages in this country.

Q9 The above definition is appropriate as it encompasses the core situations that may give rise to skills shortages in this country. Select not more than 3 factors that contribute extensively to the shortage of skills in South Africa:

- Globalization
- A dysfunctional education system; or poor education standards (Inadequate education in school (mathematics and science)
- emigration,
- crime
- HIV.
- Structural changes in the labour market;
- A general under-investment in skills development;
- Professionals leaving the industry ;
- The retirement of older professionals.
- Professional fee reduction by clients, resulting in lower salaries.
- General negative perceptions of an engineering career(i.e. long working hours for little money).
- Lack of integration of minority groups.
- Increase in the demand for new infrastructure.
- Other

Brain Drain

The Push-pull theory is a widely used approach to understand the brain drain and migration in general. The push factor is what makes a person want to leave while a pull factor is what attracts a person to a country.

Q10 What is the major cause of Brain Drain?

- Under Employments
- Economic under development
- Low wage/Salary
- Political instability
- Over production and under utilization
- Lack of research and other facilities
- Lack of freedom
- Discriminating in appointment and promotion
- Poor working facilities
- Lack of scientific tradition and culture
- Unsuitable institution
- Desire for a better urban life
- Desire for higher qualification and recognition
- Better career expectation
- Lack of satisfactory working conditions

Q11 Based on your answer in the question above, what is your reason for chosen that answer.

Q12 What is the resultant effect of Brain Drain in an organisation (people migrating from South Africa to other countries)?

Q13 Pull factors are favourable conditions that attract people to a country. These are advantages or the pros that a country has to make a person want to come live there. What would be some of the pull factors that would attract you to a country?

- Potential for employment
- Bitter service provision
- A safer atmosphere
- Low crime rates
- Fertile land
- Good food suppliers
- Less risk of natural hazards
- Greater wealth or affluence
- Political security
- A more attractive climate
- A more attractable quality of life.

Q14 What would be the solution to eliminate “Brain Drain” and the migration of skilled people from developing countries?



OUTSOURCING Versus IN-HOUSE

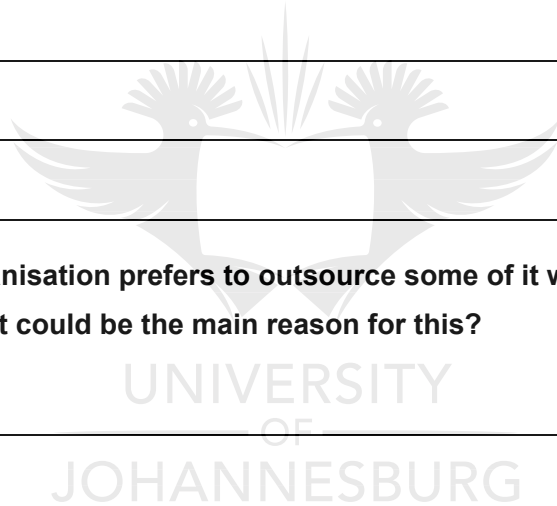
There has been an increase in the outsourcing of engineering services in the last decade. There are two categories of outsourcing. Outsourcing in terms of employing workers on contract and outsourcing of work to another company.

Q15 If you had a choice, would you rather be a contract worker (outsource your services to companies as a specialist) or be a permanent employee.

- Contract Worker
- Permanent Employee

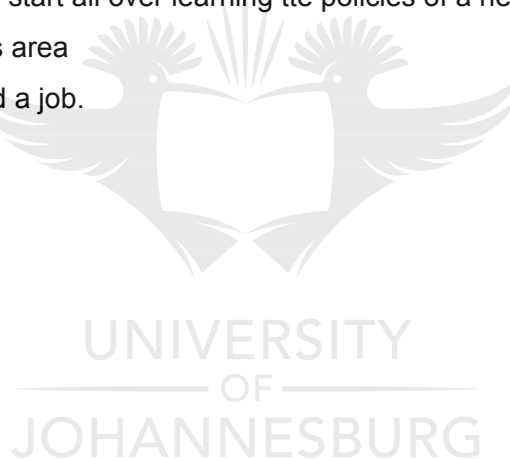
Q16 Please provide a brief reason for your answer above.

Q17 Some large Organisation prefers to outsource some of it works to other smaller companies. What could be the main reason for this?



Q18 There are various environmental reasons why employees stay at a company. What are your reasons for staying at your current company?

- I wouldn't want to rebuild most of the benefits that I have now if I left the company
- I have family responsibility
- I have good friends here at work.
- The company has been good to me and I do not believe in jumping from company to company.
- I am working to make ends meet and I do not want to take the risks in a new job.
- I would not like to the look for a job on the outside.
- I'm a little too old for starting over again
- I would not like to start all over learning tte policies of a new company.
- I like to live in this area
- It is difficult to find a job.



Leadership

Leadership is the activity of leading a group of people or an organization or the ability to do this.

Leadership involves:

- establishing a clear vision,
- sharing that vision with others so that they will follow willingly,
- providing the information, knowledge and methods to realize that vision, and
- coordinating and balancing the conflicting interests of all members and stakeholders.

Q19 Do you agree with the following statement “Leadership can be learnt?”

- Yes
- No

Q20 If you answered yes above, should leadership courses be offered at undergraduate level to assist engineers for the future?

- Yes
- No

Q21 Similarities exist between a manager and a leader. However, there are also differences between the two. What differentiates a leader from a manager? Select those characteristics below that are applicable for a leader but not a manager.

- Influential
- Integrity
- Interpersonal Skills
- Develops trust and Respect
- Prioritizes
- Team Player
- Builds consensus and
- Continuously improves
- Empowers others
- Attracts Followers
- Emotional Intelligence

- Build Teamwork
- Good Timing
- Takes calculated risks
- Helps others advance
- Develops Other leaders
- Makes Sacrifices
- Visionary
- Acts on Intuition
- Build Strong Relationships
- Leaves a Legacy
- Other

Human Management

Project human resource management refers to how a PM runs a project team. One needs to understand what resources you require to be able to successfully complete your project. After that, it is all about managing the people on the team including giving them extra skills to do their jobs,

Q22 Choose any 3 of the following major resource challenges when dealing with projects:

- Resource capacity planning is poor
- Resource risks are not assessed
- Not enough appropriately skilled resources
- Resource use is not optimized
- Schedules/deadlines are unrealistic
- Resources are assigned inconsistently
- Too many unplanned requests for resources
- Resource utilization is poorly documented
- Shifting resources to respond to problems
- Transition process for resources is inadequate
- Other

Q23 Small things' matters the most in an organizational environment, In terms of recognition, which one of the following would be seen as the most preferred means of recognition:

- Financial rewards
- Gifts
- acknowledgement
- Other

Skills Management

Q24 How many projects are you concurrently working on?

Q25 What are some of the challenges that you have experienced/are experiencing when working on multiple projects concurrently?

Q26 Within business and Knowledge Management, two types of knowledge are usually defined, namely explicit and tacit knowledge. The former refers to codified knowledge, such as that found in documents, while the latter refers to non-codified and often personal/experience-based knowledge.

In engineering which of the following knowledge are most suited to an engineering organisation:

- Explicit
- Tacit
- balance of the two

Q27 Please provide a reason for you answer to question 26?

Q28 What do you consider to be the 3 most essential skills and attributes of an engineer?

- Technical knowledge and skills, practical ability e.g. use of modern technology.
- Intellectual skills, ability to learn and understand new information.
- Attitudes, behaviour, thoughts and actions.
- Standards of engineering practice; awareness and observance of engineering codes of practice and ethics; understanding of the role of an engineer; and general knowledge of the working legislation and regulations.
- Business practices: understanding of economic and financial issues, and ability to work within a business- orientated environment.
- International/national history and culture: understanding of other cultures and customs.
- Proficiency in languages: understanding other languages and familiarity with technical language.

Q29 A projects success, is based on various aspects. Choose five factors that have the highest impact on projects' success

- Compliance with the planned budget, time frame and performance criteria
- Clearly defined goals and directions
- Accurate schedule and plan
- Timely and comprehensive control
- Adequate use of project management techniques
- Adequate use of technical skills
- Competent project team members
- Clearly defined roles and responsibilities
- Synergy of the team
- Experience and expertise of the project manager
- Adequate risk management
- Ability to handle unexpected problems
- Communication and consultation with stakeholders
- Provision of timely data to key players
- Client acceptance of the results
- Stakeholders satisfaction
- Owner involvement within the project
- Sponsor involvement within the project
- Top management support