AN INVESTIGATION OF INDUSTRY EXPECTATIONS ON INDUSTRIAL ENGINEERING GRADUATES: A CASE STUDY OF GRADUATE DEVELOPMENT PROGRAMMES IN SOUTH AFRICAN UNIVERSITIES

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ABSTRACT

During the year 2008 and 2009, post apartheid South Africa and the global community experienced major economic turbulence with poverty, unemployment and skills shortage affected by poor productivity in most manufacturing and other economic sectors leading to a subsequent downsizing of the labour work force. The government and business communities at large realized the necessity for skills development across the major economic sectors in order to resuscitate the failing economy. The solutions lay in organisations re-evaluating their current operational strategies by streamlining their organisations and adopting aggressive lean and cost saving approaches in order to remain competitive.

Two things became apparent; one was the need for skills growth and two the need for a cost cutting, cost saving and optimisation skill, a skill descriptively and applicably seen in industrial engineering. The role of graduate institutions facilitating the growth of the human capital development in the work environment has become a critical factor in South Africa, aiming at improving the productivity and economic growth of the country. In this paper, the focus confines itself on the following main areas of discussion, the institution environment with the students-lecturer relationship explored and the work environment. The study highlights the influence these environments have on industrial engineering skills and competencies attained by industrial engineering university student graduates and how this ultimately creates a way out for the South African economy.

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1. INTRODUCTION

Since the 1970s and 1980s, skills development was and still is a contentious issue within the work industry. The skills shortage in South Africa is one of the main impediments to reaching the stated economic growth targets of the Government. This has advertently made skills development crucial to South Africa’s growth and progress [9]. Two major challenges addressed during the post apartheid era, poverty and unemployment [23], called for an aggressive approach to skills development. This aggressive approach is evident by the governments’ efforts in the creation of the department of higher education and training. This has incorporated various institutional entities such as human capital development under the Human Resource Development Strategy for South Africa and the higher education bodies in cooperation with the South African Qualifications Authority in fostering skills development aiming at realising a systemised post school education and training structure.

The South African Qualifications Authority Act [18, 24], passed into law in October 1995. The act prescribed the establishment of, amongst others, the South African Qualifications Authority, the National Qualifications Framework and the Sectoral Education and Training Authorities. In addition, the introduction of the Joint Initiative for Priority Skills Acquisition together with the higher education bodies has created a renewed approach in the economic ‘skills’ needs required for improving the economic growth reaffirmed by Mlambo-Ngcuka:

“In a country such as ours where skills shortage and skills inadequacy is so glaring...In South Africa, we have missed so many opportunities because of skills. We import artisans, welders...concurrently we also need a skills revolution in the curriculum of tertiary education, as well as in the quality of public education. Human Resource Development. The biggest crosscutting constraint. The skills that we lack and desperately need are engineering skills, planning and management skills, artisans...” [9].

The evolution of industrial engineering in South Africa as discussed by MyFundi [11], began in the early 1960s with the learning ‘student’ being equipped with subjects like work-study, method studies, production, material handling, layout planning and a few financial subjects. During the 1970s, it was realised that the environment of industrial engineers was changing and that the student was entering the era of planning and scheduling. As a result, the academic syllabi changed accordingly, and the inclusion of additional subjects like Control Systems, Material Science, Operations Research, Statistical Quality Control and Computers and Programming was necessary. Industrial engineers began to emerge as engineers trained to see the 'bigger picture' in a systems perspective. It was also realised that this engineer could perform outside the arena of hard production and would enter the world of the service sectors [11]. According to Statistics South Africa [28], in 2008 and 2009, South Africa underwent a trying economic slump losing a major percentage of their manufacturing labour force. As a result, most manufacturing firms’ competitive edge pegged on re- evaluating their operational strategies by undertaking leaner more aggressive cost saving approaches. This signalled a revival for the industrial engineering field as most companies delved into streamlining their organisations by employing industrial engineering practices, techniques e.g. six sigma, continuous improvement, and taking on industrial engineering professionals. Industrial engineering was slowly gaining attention as a means to cut cost and maintain a cost effective business approach. This course of events, created a niche for industrial engineering as a much-needed value-adding component for business excellence.
Industrial engineering is a necessary skill in any developing and developed country. The need is evident by the increase in the cost saving approaches South African companies are employing. This study explores the correlation between industry skills expectations and the academic ability to meet this need. The study needed to satisfy the researchers’ enquiry in as far as the level of graduating South African industrial engineers who are actually employed within the relevant job market and the expected growth. In addition, the needs of the job industry are ideally expected to be met by the various learning institutions i.e. universities in this case, placing responsibility on both the industry and the universities to ensure that students learn what is relevant and useful for job performance and development. It is thus imperative to investigate this relationship between industry and graduate industrial engineers with emphasis on the skills expectations as emphasised by the government and the academic capacity to meet these skills expectation in today’s competitive professional arena as iterated by Nel [13].

The combined impact of the economic strain experienced by the South African economy, shows that there is a lack of adequate communication between industry and institutions, the result of which, the skills level and academic qualification attained by graduating industrial engineers do not meet industry expectations’. In making this statement, we are in fact asking ourselves the following; “Are the graduate industrial engineers able to meet the minimum demands and skills level expected by the relevant industrial engineering industry?” In answering this question, several objectives are derived and explored further in order to elucidate the bridge behind this assumed gap between the student’s skills level acquired from academic knowledge and the application of this skill within the industrial engineering environment. The objectives for this study were as follows:

- To determine the significant roles played by industrial engineering graduates in industry;
- to identify the minimum skills level of an industrial engineering graduate;
- to identify the existing academic national qualification framework for industrial engineering curricula, as defined by the South African Qualification Authority; and
- to define effective mechanisms to ensure high quality levels of industrial engineering graduates capable of meeting industry expectations.

2. LITERATURE REVIEW

2.1. Skills level and the significant role of industrial engineering on productivity

Since 1994, the skills shortage in South Africa has been of concern triggering various discussions forum in an effort to understand and articulate its dynamics and impact towards economic development [25,30]. Poverty, inequality and unemployment are continuously under debate with skills scarcity being topical [30]. Iterating further, South Africa [27], describes the gap between income inequalities in the various sectors of industry in South Africa plays a major role in the skills shortage arena. Results obtained from the 2005/6 Income and Expenditure survey, show a resounding gap between income earners in industry. Despite ten percent of the population earning more than fifty percent of household income, eighty percent of this population earns less than eight and a half percent of the household income, negating the need for skills as a source of income [25]. In addition, the unusually high unemployment rate manifests itself with a low youth count in the labour market and the education and training system [4]. The poor and ineffective educational outcome is
evident in the poor results seen in the current Annual National Assessments literacy and numeracy levels [31].

This challenge, calls for a more effective approach towards the education system and balance between labour supply and demand if there is to be an improvement in the socio-economic growth and development. Articulation of the link between the education sector and industry creates a platform for development of quality programmes in the education sector that caters directly for the needs of industry [22,32]. The department of trade and industry iterates this in the National Industrial and Policy Framework stating that ‘...the skills and education system form a fundamental pillar for the success of an industrial policy. There is currently insufficient integration between industrial policy objectives and skills in the education system. There is therefore a need for a much closer alignment between industrial policy skills and education development, particularly with respect to sector strategies...’ [26]. In light of these revelations of inequality and poor pre-schooling outcomes, an understanding of the importance of effective post schooling and supporting training systems is worth exploring in order to improve South Africa’s developmental growth and sustainability.

Industrial engineering is a branch of engineering that focuses skills knowledge geared towards effective systems development and optimisation in both product engineering and service related fields [11]. In the South African engineering context, industrial engineering is a skill viewed in various forms such as industrial technologists, industrial technicians and industrial professional engineers [19,20]. The department for Home Affairs listed industrial engineering as a national scarce and critical skill in 2006 substantiating the need for industrial engineering as a highly sort after skill [26]. According to Nel and Mulaba-Bafubiandi [12], the current number of professionally registered South African engineers in the engineering database since 2006, was five thousand for engineers, one thousand six hundred for technologists, six thousand seven hundred for technicians and as of March 2005 only two hundred and twenty five registered industrial engineers.

A 2008 statement by the Southern African Institute for Industrial Engineering, iterated that the varied characteristic of the industrial engineering profession has shifted beyond the conventional engineering applied in the manufacturing sector prior to 1950 and has widened to feature in non-manufacturing areas, which include consulting, banking, healthcare, and government. [12]. The Business Times of March 2007. The article, cited in Project2010 [15], stated “...companies are buckling under the increasing demands of a growing economy and in the face of fierce competition from international businesses, companies ‘creaking under the strain’ of a ‘skills crisis’ and the need to deliver bigger volumes of goods to increasingly diverse customers. This is compromising SA’s global competitiveness and is spurring ‘poorer’ service across various industries”...“due to the shortage of skills in engineering, supply chain management, warehousing and distribution, and network analysts...” all skills relevant to industrial engineering [15]. In addition, the discussion forum held by the SAIE industry forum in 2008 estimates that about one thousand industrial engineers are needed every year in order to meet this level of industrial engineering demand for South Africa.

2.2. Curriculum requirements and skills level

Industrial engineering focuses on the following areas of business; efficiency, or, more precisely, how to design, organize, implement and operate the basic factors of production (materials, equipment, people, information, and energy) in the most efficient manner possible. The typical focus is on optimising industrial manufacturing operations, although the skills learned are applicable to other non-manufacturing settings [33]. The following highlight a few key areas an industrial engineer must meet; both in academia and the relevant linked industry skills:
• Ergonomics / Human Factors Engineering (designing the workplace to better accommodate “human factors” (human abilities and behaviours’), thereby yielding more efficient operations and fewer accidents or injuries).

• Facility Design (aimed at operational efficiency)

• Applied statistics (using statistics and other forms of data analysis to aid in making management decisions and analysing work.)

• Manufacturing Engineering (concerned with all aspects of manufacturing operations – materials, parts, equipment, facilities, labour, finished products, and delivery, among others).

• Quality Control (using sampling, statistical analysis and other techniques to assess and maintain the quality of products or services provided by a business or other organisation)

• Work Design (defining jobs that individual workers do in performing the overall work of the organisation, with the typical focus being on optimising manufacturing operations).

• Worker Productivity (conducting time and motion studies, setting work performance standards, and proposing new/improved work methods)

In fitting the various roles of industrial engineering fields, the following main engineering disciplines in industrial engineering stand out [35]:

• **Enterprise engineering**: This is the engineering of enterprises as a whole, which evolved from systems engineering. In order to achieve this, industrial engineers make use of their ability in the application of knowledge, principles, and disciplines related to the analysis, design, implementation and operation of all elements associated with an enterprise.

• **Systems engineering**: This is the approach to design, creation, and operation of systems. It entails the identification and quantification of system goals, with the aim of integrating the needs of each related subsystem to fit the purpose of the main system. The need arose with the increase in system complexity, due to poor subsystem integration, and subsequently unstable system reliability.

• **Operations management**: Operational industrial engineering focuses on the design and improvement of operations and activities related to the functions delivered by the system role players. One such area is in the supply-chain-management operation that aims to link the organisations role players internally and externally in the system.

• **Applied industrial engineering**: This is the application of industrial engineering in specific industries. These industries may be dictated by the national economic growth needs. In South Africa, the current industrial needs fall under production and productivity growth.

• **Engineering management**: Engineering management is a specialised form of management that is concerned with the application of engineering principles to business practice. Engineering management is a career that brings together the technological problem-solving practical understanding of engineering and the organisational, administrative, and planning abilities of management in order to oversee complex enterprises from conception to completion.
2.3. Curriculation, quality assurance and academic qualification levels of industrial engineering

Higher education bodies responsible for curriculation of industrial engineering as a study programme, tasked with the mandate to formulate, standardize and monitor the current and emerging academic and non-academic qualifications, brought about a means to steer skills level towards a more productive focal point. These bodies are the South Africa National Qualifications Framework and the Engineering Council of South Africa. One body that is not included under the higher education statutory bodies but contributes immensely, by its own right, towards fostering economic growth in the business and other economic sectors, is the Southern African Institute for Industrial Engineering. SAIIE as the name implies, is an organisation made up of industrial engineering members from various disciplines drawing upon specialised knowledge and skills in the mathematical, physical, behavioural, economic and management sciences focused on finding optimal and practical solutions, which contribute to the success, prosperity and the creation of wealth in the Southern African economy. SAIIE aims to be a vibrant, learned society, representing and promoting all industrial engineers, while maintaining a high level of standard for all industrial engineers within Southern Africa [16].

The academic qualifications currently attainable in South Africa by an industrial engineer are:

- National diploma in industrial engineering with an NQF level 6,
- Bachelor of technology in industrial engineering with an NQF level 7,
- Master of technology in industrial engineering with an NQF level 9,
- Doctor of technology in industrial engineering with an NQF level 10,
- Bachelor of engineering in industrial engineering with an NQF level 8,
- Master of engineering science: Engineering management with an NQF level 9 and
- Doctor of engineering with an NQF level 10

In highlighting these broad areas of literature, the study is able to show the alignment of the two components i.e. curriculum requirements and the skills level of the graduate industrial engineer thereby narrowing the gap between the student’s skills level acquired from academic knowledge and the application of this skill within the industrial engineering environment.

2.4. Quality and Total Quality Management of industrial engineering

Total quality management is a philosophical management approach developed by several management professionals one of whom was the quality guru W. Edward Deming through his fourteen points on how to implement quality improvement. Organisations use total quality management to implement quality policies and objectives through directing and controlling a set of integrated elements in order to achieve a high level of overall operational excellence. Deming’s fourteen points were developed further into seven effective concepts namely, continuous improvement, six sigma, employee empowerment, bench marking, just in time, taguchi concepts, and the knowledge of the total quality management tools [36].

“Trends in Public Higher Education in South Africa: 1995 to 2004” [21] is a report that demonstrates the quantity of learners who have successfully passed to graduate during the period 1995-2004 and the number of qualifications registered since the inception of the outcome based National Qualifications Framework initiative. The report defines a national higher diploma in industrial engineering as a qualification with a national qualifications framework rating of seven, which will serve as an example or basis of reference throughout this study. As mentioned previously, the outcome-based accreditation of undergraduate
engineering programmes has been under discussion since the mid 1900s [8]. The accreditation emphasizes the need to produce graduates that adequately meet the needs of industry and as such, it is important to explore whether the outcomes of such engineering programmes do indeed match the needs of industry [5, 8]. It is however important to mention that alignment of the curriculum requirements and the skills level of the graduate industrial engineer is of no consequence if value is not proffered. The study proceeds to show an effective mechanism to ensure high quality levels of industrial engineers capable of meeting industry expectations in a cross section study of what it means to have quality represented in industrial engineering.

Just as any other organisation that utilises quality to gain optimum throughput through total quality management, higher education requires a quality component. Viewing industrial engineering in institutions of higher learning as a system with interrelated components, with the ‘customer’ being the product of interest such as the graduate industrial engineer, quality becomes an aspect that one is hard pressed to ignore just as in any other manufacturing process. Chikumba [3], iterates that the organisational transformation model, emphasizes that understanding organisations as a model is important for successful execution of corporate strategy and that viewing the organisation as a transformation process, which satisfies customer needs through maximizing value added to inputs producing outputs through routine and repetitive or programmable decisions is important. In defining value, the dimensions of quality should not be ignored; value accrues through the creation of the products’ function. This ideology is better described mathematically in figure 1 [10]:

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

\[
\Delta VALUE = \frac{QUALITY,\ SPEED,\ and\ FLEXIBILITY\ (Drivers\ of\ value)}{RISK,\ WASTE,\ and\ CASH\ FLOW\ (Drivers\ of\ value)}
\]

Figure 1: Operational value drivers [10]

The three main groups responsible for creating this value are considered in this paper as falling within three domains, one the industry, two the institutions of higher learning and three the student. The study measures these groups against the effectiveness and efficiency model [10]. Being effective allows an individual the ability to achieve a task given certain pertinent tools and resources. However, achieving the task in the shortest time and in the least effort relies on how efficient one is, see figure 2.
3. PROBLEM STATEMENT

There is indeed a need to investigate the relationship between industry and graduate industrial engineers, as emphasised by the skills expectations addressed by the government and the academic capability to meet these skills expectations. The problem statement developed reads as follows: ‘There is a lack of adequate communication between industry and institutions, as a result of which, the skills level and academic qualification attained by graduating industrial engineers do not meet industry expectations.’

The following question answers the aforementioned statement by asking: “Are the industrial engineering graduates able to meet the minimum demands and skills level expected by the relevant industrial engineering industry?” This led to the following set of investigative subquestions that explore the relationship between the minimum level of skills and qualification expected of a graduating industrial engineer by the relevant industrial engineering companies and businesses in South Africa by considering the following:

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

4. RESEARCH METHODOLOGY

The statistical inferences drawn are from three Likert type scale [2] questionnaires using a sample group of one hundred and fifty four participants from all three groups i.e. the students, lecturers and the industry, in the form of an online and manual survey in conjunction with several interview sessions[1,7]. The Three separate questionnaires similar in design and
nature were developed for each subgroup [1]. A distinction per questionnaire was intentionally built in through re-structuring each survey according to the environment suitable to the sub-group in question. Each questionnaire was broken into three distinct sections covering three prescribed environments of industrial engineering. Firstly the Academic environment seeking the perception of industrial engineering in as far as knowledge understanding and creation, secondly industrial / work environment seeking the perception of industrial engineering’s impact in the business organisation and lastly quality environment of industrial engineering seeking the perceived level of ‘value’ understood in this engineering skill.

The data sampled from the study were analysed using a Microsoft’s excel application programme designed and created by Del Siegle [17]. The statistical tests derived were:

- Descriptive statistics with univariate graphs.
- Cronbach’s Alpha for reliability testing.

5. RESULTS

5.1. Descriptive statistics

5.1.1. Overall analysis of student responses

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

- **Role of industrial engineering in industry:** Ninety percent of students understand and are passionate of industrial engineering and its role in industry as asked in statement 1 of the study. However there is a significant seventy seven percent and above uncertainty as to its origin, awareness and future role in industry as asked in statement 1 and 6 respectively.

- **Significance of industrial engineering in industry:** Eighty eight percent of students agreed that industrial engineering plays a significant role in industry as answered in statement 4 of the study.

- **Minimum skills level of a qualified graduate industrial engineer:** Eighty eight percent of students agreed that a minimum requirement for industrial engineering in industry is a bachelor’s degree.

- **Knowledge of the existing SAQA qualification framework for industrial engineering:** Seventy six percent of students were aware, knowledgeable and understood the workings and interpretations of the national qualification framework.

5.1.2. Effective mechanism for students:

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

5.1.3. Overall analysis of institution (lecturers) responses

The summary of the overall analysis of institution (lecturers) responses based on a significant percentage response related to discussions made within the ambit of the literature review and the investigative sub-questions highlighted in the introduction of the study, see figure 4:

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

- **Significance of industrial engineering in industry:** Ninety two percent of lecturers agreed that industrial engineering plays a significant role in industry. Its responsibility in industry and history background is of great importance in influencing the South African economy. It is encouraging to note that a negligible number disagreed with the above feedback depicting a strong sense of industrial engineering as a pertinent component in economic growth and sustainability.

- **Minimum skills level of a qualified graduate industrial engineer:** Eighty-three percent of lecturers agreed that a minimum requirement for industrial engineering in industry is a bachelor’s degree and above.

- **Knowledge of the existing SAQA qualification framework for industrial engineering:** One hundred percent of lecturers were aware, knowledgeable and understood the workings and interpretations of the national qualification framework, and what is expected for industry. Very encouraging is the fact that eighty four percent of the lectures were in total agreement as to the nature of student and industry expectations and the importance to meet this need.
5.1.4. Effective mechanism for lecturers:
A significant sixty-seven percent of lecturers agreed that they receive adequate teaching material from their institutions and poses effective teaching styles including support from institution and industry interactions that enhance the quality of the skills taught. It is important to take note that thirty-three percent of lecturers felt that they are inadequately supported in their personal capacity to teach industrial engineering. Statement 21 highlights this personal inadequacy, which begs for further investigation. This may possibly be due to the sixty-six percent in disagreement as to the following Statement 22, which states; ‘my current remuneration level is adequate given the work I do’ i.e. for lecturing services rendered. Lecturers significantly support discussion groups, family and departmental interventions. Thirty three percent and twenty-five percent of lecturers in Statement 51 and 52 respectively, agree that interactions with the quality assurance bodies such as the Engineering Council of South Africa and Southern African Institute of Industrial Engineers with their institutions help develop and keep industrial engineering current. Statement 40 although positively answered, highlights an important fact that sixteen percent of lectures do not believe that students have adequate access to industrial engineering information within their institutions’ libraries. This small percentage may be due to inadequate or inaccessible South African industrial engineering literature students are able to utilise.

5.1.5. Overall analysis of industry (SAIIE and ECSA) responses
The following is a summary of the overall analysis of industry (SAIIE and ECSA) responses based on a significant percentage response related to discussions made in the literature review and the investigative sub-questions highlighted in the study, see figure 5:

- **Role of industrial engineering in industry:** Eighty-eight percent of industry have a mastery understanding of industrial engineering and believe that it is knowledge and information based skill, which industry can capitalise on.
- **Significance of industrial engineering in industry:** Ninety-one percent of industry agreed that industrial engineering plays a significant role in industry and its responsibility in industry is of great importance in influencing the South African
economy. Of significance, however, is the forty six percent of industry who are either uncertain or do not know the significant role the history industrial engineering has played in the South African economy while only fifty three percent of lecturers are in agreement as far as being knowledgeable of the fact. The actuality that seventy-seven percent of industry disagreed as to the adequate awareness of industrial engineering in industry regionally may attest to the lack of knowledge of the history of industrial engineering in industry. It is encouraging to note that fifty-five percent of industry believed that institutions are contributing to skilling productive industrial engineers. However thirty five percent are either uncertain or disagree with the fact.

- **Minimum skills level of a qualified graduate industrial engineer:** Eighty-two percent of industry agreed that a minimum requirement for industrial engineering in industry is a bachelor’s degree and above. Industry is encouraging further development and research as shown by the ninety four percent of individual industrial engineers either involved in or pursuing industrial engineering related projects and activities, showing a positive growth and advancement of industrial engineering knowledge and innovation in industry

- **Knowledge of the existing SAQA qualification framework for industrial engineering:** Above eighty percent of industry were aware, knowledgeable and understood the workings and interpretations of the national qualification framework, and what is expected of industry. Seventy-eight percent of the industry agreed as to the nature of student and industry expectations and the importance to meet this need.

5.1.6. **Effective mechanism for industry (SAIE and ECSA):**

Only forty-nine percent of lecturers agreed that institutions of higher learning receive adequate teaching material and poses effective teaching styles including support from institution and industry interactions that enhance the quality of the industrial engineering skills taught. It is important to take note that twenty-nine percent of industry and institutions of higher learning feel that there is adequate support for them in research and development of industrial engineering. The other seventy percent are in opposition and feel that more should be done to developed industrial engineering research and development within industry and institutions of higher learning. Statement 21 however, has an eighty-nine percent agreement that industry is personally encouraged to develop industrial engineering as opposed to the lecturers’ views on this statement. Statement 24 shows eighty-six percent agreed that there is potential for further growth in studies on industrial engineering. Statement 48 shows that there is a seventy percent industry agreement that the teaching environment creates a positive attitude within industrial engineering. Under Statement 51, industry generally agree by forty three percent that institutions of higher learning actively and positively participate with quality assurance bodies such as Engineering Council of South Africa and Southern African Institute of Industrial Engineers in monitoring and controlling the quality of industrial engineering education. Fifty six percent of industry disagrees. In Statement 52, industry generally agrees that interactions with the quality assurance bodies such as the Engineering Council of South Africa and Southern African Institute of Industrial Engineers and students of higher learning institutions is present to help develop and keep industrial engineering current. Forty seven percent of industry either disagrees or is uncertain. This may be due to Statement 50, inadequate communication between industry and institutions of higher learning.
5.1.7. Effective mechanism to enhance quality industrial engineers

The interrelationship between the three quadrants, as shown in Figure 2, highlights the institutions' influence on the student's level of skills knowledge acquisition in industrial engineering and further demonstrates the interdependence between the students and industry in relation to the ability of the student in meeting the expectations industry places on their work ability. Lastly, a two-way relationship is described between the institution and the industry in building and developing materials relevant for teaching skills needed by industry to students [33].

There exists a relationship between the following aforementioned three groups, i.e. industrial engineering students, industrial engineering institutions of higher learning and industrial engineering work industries. The effectiveness and efficiency model measured the gap existing between the three groups, narrowing down to two groups. The measure of effectiveness and efficiency depicted the level of value that students need to attain employability and value in industry. The inferences developed categorise the three sample groups into two of the four quadrants of the effectiveness and efficiency model. From the analysis, it is evident that industry and academia are in accord as far as being effective in industrial engineering approach and being able to efficiently deliver this skill to the students. The students' 'fit' within Figure 6, falls within the effectiveness and inefficient quadrant ‘D’ as shown:

Figure 5: Stacked bar of industry (SAIE and ECSA) responses
It is thus evident from figure 6, that students have the necessary resources attained through their academic programmes and the adequate interaction with industry to be effective at applying the attained knowledge and skill in industry. However, how efficient and capable the students are at utilizing this skill in achieving this value in industry is a significant issue requiring further research.

5.2. Reliability Testing

A reliability measurement was conducted separately on every level of statements within the student, institution (lecturers) and industry survey based on the response given in the scale. The following lists the Cronbach’s alpha coefficients determined for each sampled questionnaire. Tavakol and Dennick [34] iterated that Cronbach’s alpha coefficients of 0.70 to 0.95 may be considered acceptable and that at times lower values in certain cases may be accepted. Based on the tabulated information, the student, institution and industry survey shows a raw variable Cronbach’s alpha coefficient of 0.979, 0.974 and 0.989, which indicates that the questionnaires were considered reliable and consistent.

Table 1: Cronbach’s alpha coefficients for each sampled questionnaire

<table>
<thead>
<tr>
<th>Sample Questionnaire</th>
<th>Cronbach’s alpha coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Survey</td>
<td>0.979</td>
</tr>
<tr>
<td>Institution (Lecturer) Survey</td>
<td>0.974</td>
</tr>
<tr>
<td>Industry Survey</td>
<td>0.989</td>
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</tbody>
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6. CONCLUSION AND RECOMMENDATIONS

6.1. Recommendations

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

- Students have the right mindset on how effective industrial engineering is in adding value in industry but are still limited in identifying with the efficiency in application of the skill in as far as ‘best fit’ is concerned. Efficiency in this case means the application of skills taught at universities of higher education.
Lecturers are adopting the right approach to teaching, motivating and developing the industrial engineering skill. Furthermore, lecturers are demonstrating various avenues of dynamically delivering the learning material by involving various facets of teaching from practice to innovative theory.

Industry fairs well in its approach to developing skilled industrial engineering students in an effort to spearhead industrial engineering as the forefront of South Africa’s economic growth and sustainability. This is evident through its involvement in the growth of practice and knowledge of industrial engineering. The manner in which this approach emerges is considerably efficient, through the curriculum development advisory bodies, industry visits, and quality assurance audits managed by the various quality assurance bodies as gleaned from the survey.

As such, the following may be addressed towards a solution to the inefficiency faced by the students:

- **Embedding of Total Quality Management principles into the learning process at universities:** According to Ho and Wearn [6], the discussion of TQM as a management philosophy and company practice, under the literature review section which aim to harness the human and material resources of an organisation, in the most effective way to achieve the objectives of the organisation; refers to the principles and tools surrounding total quality management as one way of managing institutions that provide industrial engineering as a learning programme. The opportunity is seen to develop valuable graduates, by emphasising on the human quality aspect as a resource that can be managed effectively towards efficiency.

- **A practical, hands-on approach** plays a major role as was highlighted by the industry survey in its expectations of academia in providing students with the much-needed practical exposure to be able to decide on the most feasible approach to performing tasks in industry. It is increasingly becoming difficult to cut a clear distinct line around the discipline that is industrial engineering. Due to various generic skills that have mushroomed over time that incorporate and apply a number of industrial engineering practices and skills, such as continuous improvement being a part of management practices and newly created professions such as change managers among others. This has placed the industrial engineering skill as becoming a grey discipline, creating more confusion within industrial engineering student learners. The need to clarify the role of industrial engineering within industry and through the inclusion of case study teaching methodologies in academia that focus on specific application of industrial engineering skills to specific problem areas should be considered a priority.

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

### 6.2. Conclusion

The skills shortage remains a topical issue for South Africa. The study has at some level; clearly demonstrated the need for further development of innovative academic approaches that will develop better-equipped graduates. The study suggests the following:
• Attaining value in students; through the introduction of industrial engineering societies in institutions of higher learning. This will ultimately fuel interest and develop industrial engineering.

• Support of lecturing staff and institutions of higher learning through research, knowledge development and enterprising projects pertinent to current industry needs.

• Building on the current communication that exists between the industry and institutions of higher learning through advisory boards among other forums by enriching the current one way feedback (industry to academia), to a two way communication i.e. involving lectures in industry decision making process of company strategies.

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

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

REFERENCES


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