

## BALANCING EMPLOYMENT AND ENTREPRENEURSHIP REQUIREMENTS IN INDUSTRIAL ENGINEERING EDUCATION

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### ABSTRACT

The purpose of higher learning is to equip students with the necessary skills and knowledge to support their respective professional careers. Ultimately, each career follows the employment or entrepreneurship path. The higher learning curriculum is generally more structured for the employment path, even though the global economy of the 21<sup>st</sup> century is fast becoming largely entrepreneurial. This work investigates the scope of entrepreneurship in the context of industrial engineering graduates. The aim is to develop a method to determine quantitatively the importance of focusing on entrepreneurial competence development in engineering students, and to propose a strategy to address the evident need for a greater emphasis on entrepreneurial competencies in graduate industrial engineers, based on market data. The approach is to analyse entrepreneurial projects as advertised by on-line freelance platforms, to determine the general characteristic skill-level requirements and perspectives on opportunity and remuneration. A strategy to enhance graduate entrepreneurial competency is also presented.

### OPSOMMING

Die doel van hoër onderwys is om studente met die nodige vaardighede en kennis toe te rus om hul onderskeie loopbane te ondersteun. Elke loopbaan volg uiteindelik 'n werknemer of entrepreneurskap roete. Die hoër onderwys kurrikulum is in die algemeen beter gestruktureer vir die werknemer roete, selfs al is die globale ekonomie van die 21<sup>e</sup> eeu toenemend entrepreneurskap georiënteerd. Hierdie artikel ondersoek die omvang van entrepreneurskap binne die konteks van gegradueerde bedryfsingenieurs. Die doel is om 'n metode te ontwikkel om die belangrikheid van entrepreneurskap gefokusde ontwikkeling van ingenieurswese studente kwantitatief te bepaal. Daarna word 'n strategie voorgestel om 'n groter klem op entrepreneurskap vernuf te plaas. Die benadering ontleed eers entrepreneurskap projekte soos geadverteer op vryskut platforms om sodoende die algemene vaardigheidvereistes en uitsigte op besoldiging te bepaal. 'n Strategie om entrepreneurskap vaardighede te verbeter word ook voorgelê.

## 1 INTRODUCTION AND BACKGROUND

In today's economy, entrepreneurship is rapidly presenting more employment opportunities than conventional employment, especially for graduates; yet the curriculum still generally prepares graduates for formal employment rather than for entrepreneurship. Not only is entrepreneurship creating more opportunities for graduates, but it is also making a substantial contribution to national economic and social development. In recent decades, therefore, most global education systems have incorporated and promoted entrepreneurial studies into their conventional study programmes. Devadiga [1] and Azemi [2] demonstrate that promoting entrepreneurship in higher learning has a significant economic impact, especially on job creation and industrialisation.

## 1.1 Research question

Given the global trend of an increasing trajectory of entrepreneurship in various trades, this paper presents the main research question: Can an integrated method be developed and standardised to analyse the importance of promoting entrepreneurial competencies in graduate industrial engineers as a way of improving their career prospects? On the basis of such a method, justifications and motivations could be offered to support national and global calls to improve entrepreneurial competencies in the engineers of tomorrow. A subsequent sub-question is that, if the method in question could be developed and standardised, what would some of the key factors be to consider when determining the extent to which industrial engineering education must account for graduate entrepreneurship – and balance it with employment requirements?

In simple terms, an entrepreneur can be defined as one who is self-employed [3]; in other contexts, the term 'freelancer' is used. Industrial engineering entrepreneurs would therefore typically start businesses that provide industrial engineering services. According to [4], entrepreneurship (freelancing) is in fact becoming the dominant form of business enterprise throughout the European Union. This is also true for South Africa and other African nations. However, different professional fields have different potentials for entrepreneurship. The field of computer science is ranked high globally in respect of graduate entrepreneurship opportunity. Typical entrepreneurial projects in this field include web development, graphic design, mobile application development, and software and database development.

Artisanship is also ranked high in terms of entrepreneurship opportunities, especially for trades related to the construction sector such as artisan electricians, plumbers, and carpenters, and other trades such as beauty care and boiler-making. The odds that entrepreneurial ventures will be successful and sustainable are generally high in these fields.

What are the entrepreneurship prospects, then, for the industrial engineering graduate? It is necessary to research and determine the realistic potential for entrepreneurship in the context of industrial engineering graduates in South Africa. A standardised method that is supported by industry-based data is therefore required to estimate clearly the significance of enhancing entrepreneurial competencies. Having developed this method, the aim would then be to determine the extent to which the curriculum must be adjusted to accommodate entrepreneurial competencies in students over and above employment-related competencies, and to propose a strategy of implementation.

## 2 LITERATURE REVIEW

To understand the potential benefits of promoting graduate industrial engineering entrepreneurship through the curriculum, it is necessary initially to study the general attributes of entrepreneurship. It must be noted, though, that for different career paths or trades, prospects in entrepreneurship have different potential. In this study, the potential for industrial engineering graduates is investigated.

### 2.1 Graduate entrepreneurship

According to Birch *et al.* [5], students have generally been educated more to be employees, not business owners. The study shows that, while students are willing to become entrepreneurs, the higher learning curriculum content does not adequately address the wishes and ambitions of aspiring entrepreneurs. Davey *et al.* [6] point out that, until recently, discussions about how universities could contribute to entrepreneurial support had lacked academic focus and consistency. Entrepreneurship is usually believed to be an unstable career path, given uncertainty about job security. The work of Failla *et al.* [7] challenges this belief, however, and presents entrepreneurship as a path of potential stability. Kluge *et al.* [8] discuss entrepreneurship as a solution to the problem of youth unemployment – a problem that has reached alarming levels, such that the youth unemployment rate in some cases is up to three times higher than that of adult unemployment. In the same study it is argued that, if youth were given the opportunity to innovate and to develop and practise the appropriate skills, they might accelerate progress with the 2030 Agenda for Sustainable Development.

### 2.2 Entrepreneurship and higher learning

Beyhan and Findik [9] argue that universities are diverse in their resources and competencies, especially in respect of research and development, and that such environments are highly conducive to innovation and the creation of start-ups. They argue that, if universities harnessed the available resources to support students in developing entrepreneurial competency and in starting their own ventures, a significant and positive impact on the economy and on society could be expected. Holler and Vorbach [10] present

entrepreneurship as a topic of high priority in university policies around the world, although, in some cases, it is still under-represented in engineering education. They present entrepreneurship as key in driving innovation for economic development. In [11], the researchers aimed to model the impact of entrepreneurial attitude on self-employment among final-year engineering students at three higher learning institutes in Ethiopia. The study showed that 57.4 per cent of the students had a positive post-graduate entrepreneurship mindset. The study also revealed that, while it is important for universities and governments to develop programmes that support entrepreneurship, the attitude of students to a career in entrepreneurship needs to match it. The curriculum is therefore required to promote entrepreneurship.

Herman and Stefanescu [12] investigate the potential for higher education to stimulate entrepreneurship among graduate engineers and business students. The aim is to increase the entrepreneurship mindset among students. Joao and Silva [13] also explore the potential for entrepreneurship among students and conclude that there is a need to put more effort and resources into developing entrepreneurial characteristics in students. Cheng *et al.* [14] analyse the problems that engineering education typically encounters with entrepreneurship and propose a training programme for engineering students that integrates entrepreneurial education with core studies in the form of a training package.

### **2.3 Importance of entrepreneurship**

The idea of establishing start-up, business, or innovation hubs and parks at universities and colleges is a typical illustration of how the academic world is shifting towards strongly appreciating the importance of student entrepreneurship. This idea is discussed by Jiang [15] in the context of China; the study emphasises the vitality of entrepreneurship in any economy. Santateresa [16] highlights that the promotion of entrepreneurial skills in all higher learning programmes is beneficial and would be worth exploring. Santateresa's work proposes problem-based learning to promote entrepreneurship among graduates, arguing that, at its best, higher learning would naturally and effortlessly prepare students for entrepreneurship, and that this could be realised by implementing more problem-based learning.

Hernández-Sánchez *et al.* [17] take the discussion of the importance of promoting entrepreneurship a step further, arguing that there is a need for government policy intervention, especially to prioritise financial support for training programmes. While national policy support is vital, Abayomi and Asimiran [18] argue that higher learning institutions must develop their own internal policies that support entrepreneurship. Higher learning institutions might need to establish entrepreneurship objectives at faculty or school level in order adequately to address the need to promote entrepreneurship explicitly across all higher learning programmes.

### **2.4 Student perspective**

Whether or not students are motivated for or interested in pursuing entrepreneurship, several studies have been carried out, such as those outlined in [19] and [20]. In general, studies show that interest is high from the student perspective and that, with adequate guidance and support, there is substantial potential to promote social and economic development through entrepreneurship. The question, then, would be how higher learning institutions could address such entrepreneurship needs. Wakkee *et al.* [21] show that graduates generally value entrepreneurship as a career path, but that many find this journey difficult and filled with obstacles, some of which – for example, national investment policy – are beyond the control of the prospective entrepreneur. Rummel *et al.* [22] discuss some of the obstacles that hinder graduate entrepreneurship, including the lack of orientation and of entrepreneurial characteristics.

### **2.5 Entrepreneurship scope for industrial engineering graduates**

It is evident that entrepreneurship is becoming a key element of higher learning, and that it is worth exploring the scope of entrepreneurship for graduate industrial engineers. The need to promote entrepreneurship in higher learning is highlighted well in the literature. The possible solutions or strategies to address this need are also discussed in the literature from both pedagogical and curriculum perspectives. According to the literature, the need to amplify the emphasis on entrepreneurial competencies, especially in engineering students, is clear. The importance of such competencies is spelt out in terms not only of economic development, but also of social and sustainable development; and several studies have exposed the need to emphasise entrepreneurship more in the curriculum. As calls for a greater emphasis on entrepreneurial competencies in graduates increase, so does the need for standardised systems to qualify and quantify the benefits of an improved emphasis on entrepreneurial competencies in graduates. More could be done in this regard, and this gap is explored in this study.

### 3 RESEARCH METHODOLOGY

This study proposes a standard method to evaluate the need for a greater emphasis on entrepreneurial competencies in engineering graduates, based on an analysis of industry-related data. To investigate the scope of entrepreneurship in the context of graduate industrial engineers, data was collected from on-line freelancing platforms. These platforms reflected the current trends of the industry and the current needs presented by the players within the industry as far as industrial engineering entrepreneur services were required. A quantitative approach was adopted for this study, which involved an analysis of distribution trends across a set of indices sourced from secondary sources. A quantitative approach was adopted because statistical data was available that could be analysed to determine the characteristics of entrepreneurial opportunities in a measurable way.

Typically, industrial engineering freelance jobs/projects that are posted include such tasks as these:

1. Design a self-sanitising door handle.
2. Design and develop a gear system for a mobile robot.
3. Develop a check-in system.
4. Develop a concept for a folding gate.

The individual job/project posts carry additional information such as the type of contract on offer (short- or long-term, once-off or permanent), the minimum skill required, and the applicable financial reward. As an illustration, the first post (to design a self-sanitising door handle) is characterised as follows:

1. Project timeline – five days (six hours per day)
2. Required skill level – intermediate
3. USD 80 flat payment upon completion

When hundreds of case studies are considered, it is possible to point out the feasibility of successful entrepreneurial ventures, ultimately supporting or discouraging the need for a greater emphasis on entrepreneurial competencies. This research design was adopted because the design pivoted on data that was readily available and enabled the direct translation of the state of the entrepreneurial space into interpretable information. This study was conducted in the context of South Africa.

#### 3.1 Data collection

The data was collected through a survey by analysing a number of different job/project posts in order to give an indication of the trends of activity in the entrepreneurial space for industrial engineering. The proposed method to give this indication was based on the investigation of the following indices:

1. The types of projects posted (type rating).
2. Required skill level.
3. Financial perspective.

These factors were essential to determine the viability of entrepreneurship in the context of graduate industrial engineers. This was also useful in establishing the extent to which entrepreneurial potential should be allowed to influence the curriculum.

#### 3.2 Data evaluation

In establishing the prospects of entrepreneurship from the data collected, the data collected from employment job posts was evaluated. This involved collecting the data of employment job advertisements in the field of industrial engineering and then assessing it for the given indices of interest. By analysing data samples, it was possible to determine some trends for the three indices of interest and so to evaluate the entrepreneurship potential in respect of employment.

#### 3.3 Data sampling

Probability sampling was applied to a data sample of 400 entries of job/project advertisements. To optimise the results of the study, the data sample used for this study was in a continuous form, and the total sample covered about twenty-one days of entrepreneurial job/project posting activity. The data sample contained only industrial engineering posts that required different levels of applicant skill and rewarded the various projects differently.

## 4 RESULTS, DISCUSSION, AND INTERPRETATION OF FINDINGS

This section discusses the results obtained from the methodology described above. These results ultimately led to an evaluation of the methodology as a strategic way to analyse the importance of promoting entrepreneurial competencies in graduate industrial engineers, and so to motivate for the balancing of entrepreneurial and employment requirements in the curriculum. At first, we investigated the potential significance of entrepreneurial competencies in graduate engineers, using the proposed methodology – i.e., we studied the project type ratings of graduate entrepreneurship opportunities, then the skill requirement index, and finally the financial perspective. We then extended the investigation to address what might happen if the curriculum were to be adjusted in line with the recommendations that emerged to optimise the curriculum for entrepreneurial competencies, and to determine the impact of this adjustment using a financial perspective index. A data sample of 400 different job/project posts was analysed. The useful indices from the data were then interpreted.

### 4.1 Entrepreneurial potential

To answer the question about the potential of entrepreneurship for industrial engineering graduates, the characteristics of the entrepreneurial opportunities are analysed.

#### 4.1.1 Project type

At the beginning we studied the general distribution of entrepreneurship projects in respect of their length. Figure 1 presents an analysis of industrial engineering project lengths, based on 400 different on-line freelance advertisements.

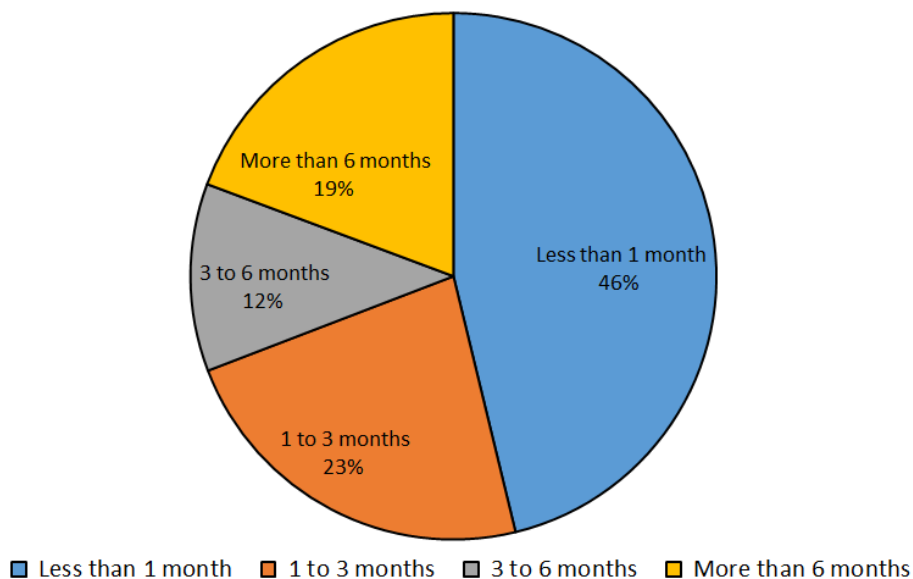
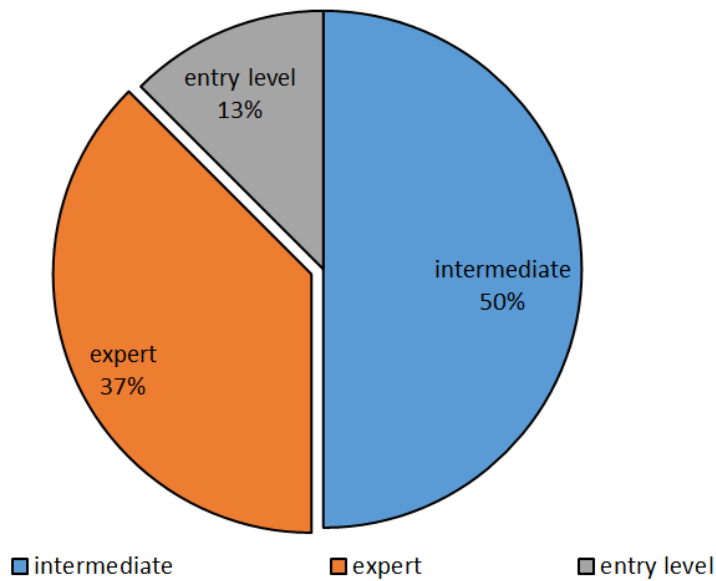


Figure 1: Distribution of industrial engineering entrepreneurial projects

It is evident that 46 per cent of the projects were short-term – i.e., less than one month in length. These projects typically involved design tasks, mostly requiring completion within a few days. The long-term projects (more than six months) constituted only 19 per cent, with some stretching even to one year in length. This shows that, while long-term projects are preferable because of the security that long-term contracts provide, short-term projects are more common for the entrepreneur. One benefit of this scenario, though, is that skill diversity is promoted, given that the entrepreneur is exposed to a wide range of different projects.

#### 4.1.2 Skill requirement

The typical job/project posting will list the minimum requirements for the applicant to meet. One such requirement is the skill (experience) level. Graduates stand at the bottom of the experience ladder, and typically qualify for jobs or projects that require the minimum of experience – typically less than two years. It is necessary, therefore, to establish the distribution of entrepreneurial jobs/projects in respect of the minimum skill and experience requirements. Figure 2 presents an analysis of the skill level requirements from 400 different on-line freelance project postings.



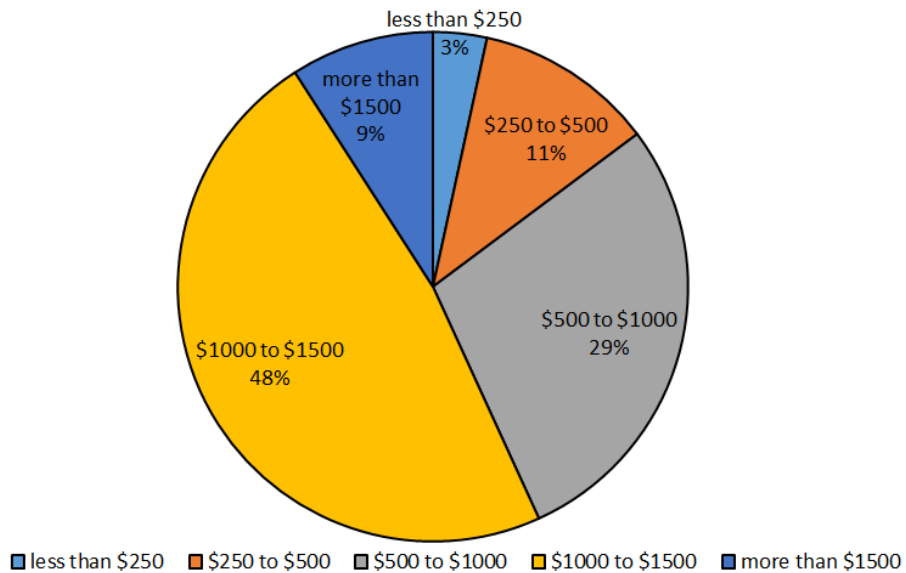
**Figure 2: Distribution of industrial engineering entrepreneurial projects by skill level**

Figure 1 shows that 50 per cent of the industrial engineering project owners required an intermediate skill level to complete a project. This skill level typically represents engineers with between one and three years of work experience. The graduate industrial engineer, however, typically falls into the entry level bracket, which according to Figure 1 shrinks the graduate’s opportunities to only 13 per cent of the industrial engineering projects. An opportunity reach of 13 per cent is rather low and suggests that the scope for entrepreneurship and freelancing for graduate industrial engineers in the current economy is limited. In this study, however, it is argued that the opportunity reach for the graduate could be widened to beyond 50 per cent purely through curriculum manipulation. As mentioned earlier, the traditional curriculum is biased towards the employment path rather than the entrepreneurship path; hence the low opportunity reach of 13 per cent. In section 4.5 of this paper, we propose a cocktail of curriculum adjustments that could widen the opportunity reach of the graduate from 13 per cent to 63 per cent (13 plus 50 – i.e., entry level plus intermediate skill).

It helps, therefore, to study the opportunity horizon of the graduate in two parts: ‘series A’ (13 per cent opportunity-reach) – that is, the graduate without strong entrepreneurial exposure in curriculum – and ‘series B’ (63 per cent opportunity horizon) – that is, the graduate with strong entrepreneurial exposure through a refined curriculum, as proposed in Section 4.3. The BEng qualification is more suitable for the exploration of entrepreneurial opportunities because a fair proportion of the entrepreneurial projects or tasks demand engineering design skills, especially for mechanical design.

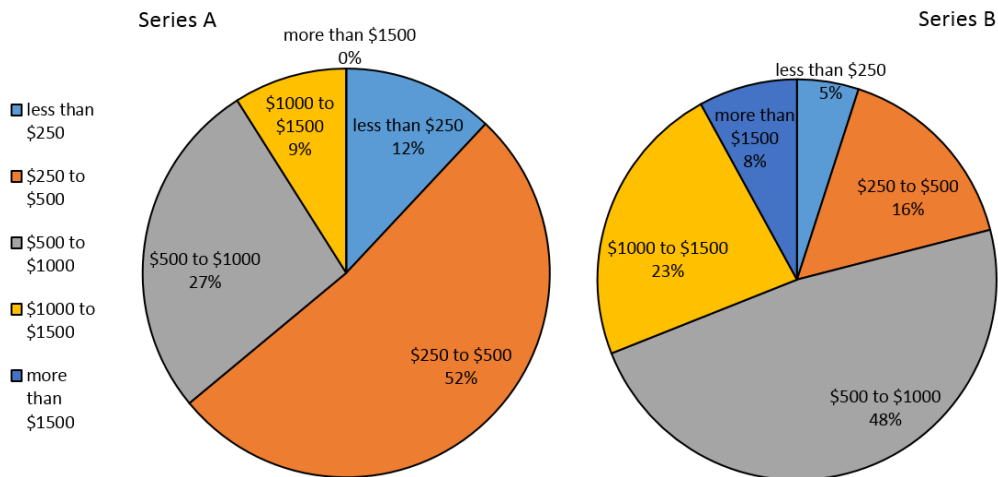
#### **4.1.3 Financial perspective**

The final factor that was considered was the financial perspective (potential earnings). It was necessary to study the financial sustainability of graduate industrial engineering entrepreneurship. If there were financial sustainability, this would support the need to reform the curriculum to include entrepreneurship. Figure 3 depicts the financial earning perspective of entrepreneurship, changed from a project basis to a projected monthly income basis for clearer presentation.



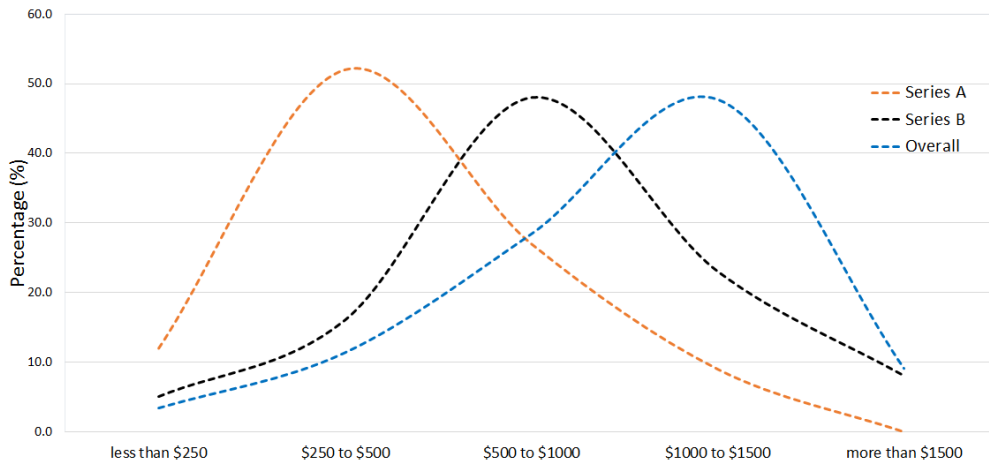
**Figure 3: Overall financial perspective**

It is evident that, in general, around 48 per cent of the 400 industrial engineering projects and jobs would pay the entrepreneur between USD 1000 and USD 1500 a month for an average of 30 hours per week. This, however, included some projects that were restricted to the expert level of experience, for which graduates would not qualify. It was necessary, therefore, to streamline the data set to consider the financial perspective of only the projects that were accessible to the graduate – i.e., the series A and B types, as depicted in Figure 4.



**Figure 4: Series A and B financial perspectives**

It is evident that it would be possible, with some adjustments to the curricula, to improve the entrepreneurial prospects of graduate industrial engineers significantly. To illustrate this finding more graphically, the distribution of the financial perspectives is presented in Figure 5, showing the Series A and Series B income distribution, which represents the graduate, and the overall distribution, which includes expert-level projects.



**Figure 5: Distribution of financial perspectives**

It is clear that the curriculum could in fact shift the financial perspective distribution curve rightwards – i.e., from Series A to Series B – by increasing the mean earning from about USD 350 to USD 750, thus improving the income. Given the assumptions that:

1. The graduate is competent and possesses the essential technical and entrepreneurial knowledge;
2. The graduate has created a compelling and comprehensive profile with a strong portfolio; and
3. The graduate has access to the relevant required software;

it could be concluded that, if successful in securing freelance work, a graduate industrial engineering entrepreneur would most likely secure several short-term projects/jobs, potentially earning between USD 1,000 and USD 1,500 a month.

However, this information was insufficient to answer the question about the extent to which entrepreneurial needs should be allowed to affect the curriculum. To answer this question adequately, the entrepreneurial opportunities needed to be evaluated against the employment opportunities. To make this evaluation, 400 industrial engineering postings of on-line recruitment (employment) advertisements were considered for comparison against the 400 freelance postings. The following facts were established from the employment postings:

1. All cases had offers that were valid for at least 12 months.
2. Only 7.5 per cent of the jobs were entry-level (less than one year's work experience). The intermediate skill level calls stood at 85.5 per cent, while seven per cent of the cases demanded an expert skill level.
3. 62 per cent had a remuneration range of USD 500 to USD 1,000 a month, while the remaining 38 per cent paid between USD 1,000 and USD 1,500 a month.
4. The 400 posts covered a period of about seven months.

With this information, it was possible to compare the trends of the employment opportunities with those of the entrepreneurship opportunities in order to guide the decision about balancing entrepreneurship and employment requirements.

#### 4.2 Cumulative analysis

To answer the question about the degree to which industrial engineering education needs to account for graduate entrepreneurship, a cumulative analysis was made of the three indices discussed above. Figure 6 compares the trends of employment opportunities against entrepreneurship opportunities. The evaluation was based on a likelihood table – that is, given an industrial engineering employment or freelance job/project advertisement, to assess the opportunity for the graduate engineer in either case.



Opportunity likelihood	Employment	Entrepreneurship	
		Series A	Series B
Graduate opportunity	0.075	0.130	0.630
<b>Contract length likelihood</b>			
Less than 1 month	0.00	0.462	
1 to 3 months	0.00	0.230	
3 to 6 months	0.00	0.115	
More than 6 months	1.00	0.193	
<b>Financial perspective likelihood</b>			
Less than \$250	0.00	0.120	0.050
\$250 to \$500	0.00	0.520	0.160
\$500 to \$1000	0.63	0.270	0.480
\$1000 to \$1500	0.37	0.090	0.230
More than \$1500	0.00	0.000	0.080

**Figure 6: Likelihood table**

The findings from Figure 6 can be summarised as follows:

1. Graduate employment provides unmatched security in terms of the length of the term of the work compared with freelance work, which typically involves multiple small projects.
2. However, the graduate has a greater chance of securing freelance work than graduate employment, especially with an improved entrepreneurship-oriented curriculum.
3. Graduate employment will typically guarantee the graduate monthly earnings of between USD 500 and USD 1,500, while freelance work is more spread out, stretching from as little as USD 100 to as much as USD 2,000 a month.
4. Revising the curriculum more strategically to promote entrepreneurship (freelancing) could increase work opportunities for the graduate fourfold. The diversity of freelance jobs further exposes the graduate to a wider range of projects, thus building up their competence more strategically.

There is scope in developing methods to analyse the importance of promoting entrepreneurial competencies in graduate industrial engineers, allowing a clearer understanding of the need to balance the employment and entrepreneurship requirements. The entrepreneurial needs should be allowed to affect the curriculum to a large extent. However, an element of professional development is required in the curriculum to accompany the shift to promoting entrepreneurship. This element would ensure that graduates venturing into entrepreneurship gained some insight into professionalism – a characteristic otherwise gained through formal employment.

It should be noted that most of the industrial engineering projects/jobs require specialised software tools that can be very expensive, and thus would be out of the reach of the freelancer – especially if recently graduated. In manipulating the curriculum to accommodate entrepreneurship needs, it would therefore be worth incorporating free open-source design software into the curriculum.

### 4.3 Proposed curriculum manipulation

To achieve the series B competence (Figure 4), some adjustments to the curriculum would be required that are proposed in this section. Over and above the inclusion of an entrepreneurship course in the curriculum, it is proposed that the entrepreneurial experience of the student be improved during the study process. To achieve this goal of promoting entrepreneurship through the curriculum, it is proposed that a unique case-study approach be taken, in which students are required to complete a set number of practical industry-based freelance work projects as part of their study experience. The freelance work would need to be industry-related, be sourced from project advertisement platforms, and comprise projects such as the 400 considered in this study, which reflect the true and current needs of industry. Each student would be

required to present their project for evaluation in class by both the lecturers and the other students. The proposed evaluation criteria would be:

1. The approach used in solving the problem.
2. The technology or software used.
3. How the project or job was secured.
4. The financial perspective of the project or job.
5. The literature review and the research methods used.
6. A sustainability perspective.

In completing these projects, not only would the student develop their skills, but they would also build a personal professional portfolio in the field of industrial engineering. Including this component in the curriculum would expose students to the industry. By the end of the study programme, each student would have solved real industry problems, potentially earning income in the process. This approach would be expected to make the series B scenario possible, thus justifying the promotion of entrepreneurship in the curriculum.

#### 4.4 Justification

The method used in this study to determine quantitatively the significance of enhancing entrepreneurial competencies in engineering graduates was based on a project-type rating analysis, a skill requirement index analysis, and a financial perspective analysis. This was supported by real data collected from the industry, and a strategy for implementation was proposed. As a way of justifying the methods employed in this study, an investigation into the impact of global or national disasters on industry (respective of entrepreneurship and employment) was conducted. This analysis focused on the Covid-19 pandemic in order to establish how both the employment and the entrepreneurship dynamics were affected by the pandemic.

Data was collected to study the distribution of employment job posts and freelance project posts over the period from June 2020 to September 2020 – a period that was affected by Covid-19. Figure 7 shows the resultant distribution.

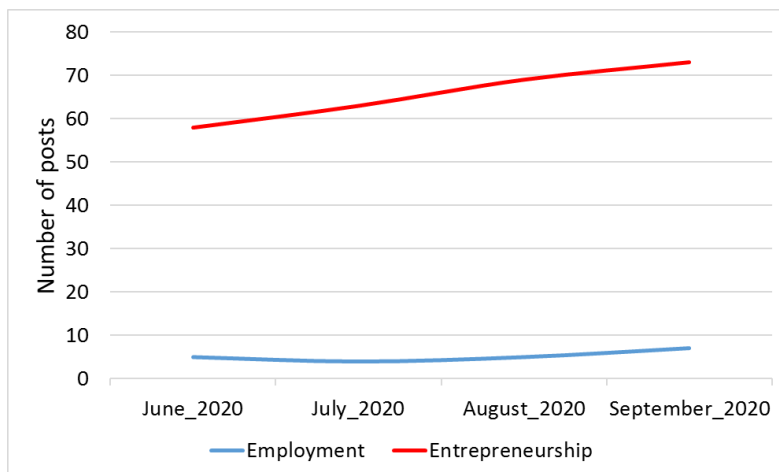


Figure 7: Distribution of job/project posts, June to September 2020

Figure 7 shows that, while Covid-19 affected the whole of the South African industry, different trends were reported from the entrepreneurial and employment sides of the economy about opportunities in industrial engineering. A rise in opportunities was reported for freelancers, while employment opportunities maintained relatively unchanged at a low level. Graduates who had developed entrepreneurial competencies during this period would therefore have had a better chance of advancing their careers than those who were focused more on employment.

## 5 CONCLUSIONS AND RECOMMENDATIONS

For any qualification, the potential for post-graduation entrepreneurial ventures is vital, especially given the current economy, which is characterised by high youth unemployment rates. Should universities therefore invest in balancing entrepreneurship and employment requirements in the curriculum? In this

study we have shown that it is possible to design and implement a method to analyse the importance of promoting entrepreneurial competencies in graduate industrial engineers. The method quantitatively determines the importance of emphasising entrepreneurial competencies in the engineering curriculum in order to balance the entrepreneurial and employment requirements. Such a method is important to motivating a greater emphasis on entrepreneurial competencies because it introduces a more factual approach to the discussion of balancing employment and entrepreneurship requirements. Using entrepreneurial project-type ratings, skill requirement indices, and some financial perspective analyses, the proposed method explicitly justifies a greater emphasis on entrepreneurial competencies in the curriculum.

These three factors have been shown to be important to consider when determining the need to emphasise graduate entrepreneurial competencies. We relied on the financial perspective analysis of the industry data to show that, in fact the engineering curriculum were optimised for entrepreneurial competencies, graduates would potentially benefit from improved opportunities for earning an income. An implementation strategy has been proposed to realise the required curriculum optimisation. The proposed strategy would meet the need to be feasible, practical, and effective, and is justified by a cross-reference analysis of the impacts of global disasters on industry, particularly focusing on the Covid-19 pandemic. In summary, the importance of emphasising entrepreneurial competencies in graduates has been presented. It is recommended that entrepreneurial competencies become a standard and key component of the industrial engineering curriculum as a way to balance the requirements for both employment and entrepreneurship. It is recommended that the call for an emphasis on entrepreneurial competencies in higher learning curricula be supported by methods that factually present the gains of the initiative. Such approaches present a motivation for the required improvements at policy level.

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