

**ENGINEERS AS ENTREPRENEURS:  
ENTREPRENEURIAL ORIENTATION OF ENGINEERS IN SOUTH AFRICA**

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**ABSTRACT**

A positive relationship between economic growth and entrepreneurship has been widely established. The entrepreneur is the key player in the entrepreneurial venturing process. This paper primarily focuses on understanding the behavioural phenomenon of entrepreneurial orientation (EO), specifically that of engineers in the South African context. The assumed EO of entrepreneurial engineers was expected to be higher than that of non-entrepreneurial engineers; and this study found this to be true of some aspects of EO. Factor analysis results supported the view that the EO construct is unidimensional. A secondary situational analysis highlighted the lack of entrepreneurial education in South Africa.

**OPSOMMING**

'n Positiewe verwantskap tussen ekonomiese groei en entrepreneurskap is reeds wyd bevestig. Die entrepreneur is die kern rolspeler in die entrepreneurskap proses. Hierdie studie fokus primêr daarop om entrepreneurskap oriëntasie (EO) as 'n gedragverskynsel van spesifiek ingenieurs in 'n Suid-Afrikaanse konteks te ondersoek. Die verwagting was dat die aangenome EO van entrepreneurskap ingenieurs hoër sou wees as dié van nie-entrepreneurskap ingenieurs en hierdie studie dien as bewys dat dit geldig is in veral sommige van die aspekte van EO. 'n Faktoranalise ondersteun die siening dat EO as 'n konstruk uni-dimensioneel is. 'n Sekondêre situasionele ontleding beklemtoon verder die gebrek aan entrepreneurskap opvoeding in Suid-Afrika.

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## 1. INTRODUCTION

The success or failure of transitional economies such as that of South Africa has been attributed by many to the performance of entrepreneurs (McMillan & Woodruff, cited in Minniti & Levesque [19]). An entrepreneur is defined as one who organises, manages, assumes the risks, and reaps the benefits of starting a new entrepreneurial venture [26]. New entrepreneurial ventures have been found to be instruments of change and growth for economies [1]. Entrepreneurs as individuals are an essential part of the process through which these new ventures are created [2]. It should also be noted that some aspects of their behaviour and cognition play a role in their entrepreneurial abilities. The social environment of which individuals are a part shapes the behaviours and cognition that either promote or hinder entrepreneurial activity [6].

Emerging economies such as that of South Africa face daunting economic development challenges [25]. The positive relationship between entrepreneurship and economic growth, particularly in developed economies, is well documented. Ireland *et al* (2001), cited in Wang [24], indicate that the heart of entrepreneurship is wealth creation. Aloulou & Fayolle [1] agree that entrepreneurial ventures are an engine of change and growth for any economy, and that the entrepreneurial attitude fuels them. As a result of the understanding of the correlation between entrepreneurship and economic growth, West *et al.* [25] (citing Acs, Birch, Kirchoff & Phillips, Romer) argue that entrepreneurial development is seen by many governments as a gateway to economic vitality, enhancing the prospects for self-generating innovation and future growth, and yielding qualitative improvements to an area's social and economic fabric.

As part of economic development - and as a solution to social issues such as high unemployment rates (estimated at 25%) - South Africa has identified small enterprise development as an increasingly important avenue for job creation and economic growth [22]. Currently, entrepreneurial activity in South Africa is low compared with that of other developing nations. For example, South African entrepreneurs contribute only 35% of gross domestic product (GDP), compared to the 60% of developing economies like India and Brazil [18].

Given that context, the main focus of the study is to understand the behavioural phenomenon that has been termed the 'entrepreneurial orientation (EO) of engineers', as the literature has established that this is a personal trait that differentiates entrepreneurs from non-entrepreneurs (Baron & Ward [3], cited in Pownall & Lawson [20]). The study's population focuses on the engineer as the unit of analysis. Esbach [8], reporting on a study of the relevance of engineers as entrepreneurs, highlights the importance of this professional group in advancing entrepreneurship. The author points out that engineers, with their innovation-channelling skills, generally create an array of entrepreneurial products embracing the economic advantages mentioned above.

This study endeavours to determine the entrepreneurial orientation (EO) of engineers in South Africa as a factor contributing to economic growth. Lacquet, cited in Esbach [8], claims that engineering has, over time, underpinned and continues to underpin economies around the world. It is further asserted that, although technological advances have introduced rapid change to meet the demands of modern society, this change continues to be integrative and iterative, so that engineering remains a stable element of economic structure. Coetzer, in Esbach [8], suggests that engineering entrepreneurship could help to create the engine that drives the economy of South Africa. The author concludes that the combination of management and engineering provides an ideal underpinning for technology innovation and entrepreneurship. The main objective of this research was therefore to study the EO of two groups of engineers: the entrepreneurial and the non-entrepreneurial.

## 2. RESEARCH APPROACH

The main objective of this research is to investigate the EO of engineers in South Africa. The literature in this field suggests that EO has five dimensions: innovativeness, risk taking, proactiveness, competitive aggressiveness, and autonomy. The study compared the EO of entrepreneurial and non-entrepreneurial engineers. On the basis of the literature, it is expected that the EO of entrepreneurial engineers on all five dimensions will be higher than that of non-entrepreneurial engineers. The scope of this study is limited to understanding the EO of engineers both in employment (non-entrepreneurial engineers) and in self-employment (entrepreneurial engineers) environments in South Africa. The secondary objective was to understand the situational factors that promote or hinder entrepreneurship in the country, and to establish the entrepreneurial intention of this group of engineers.

The following research propositions apply:

**Research Proposition 1:**

Engineers who are entrepreneurs will measure significantly higher on the innovative orientation score than non-entrepreneurial engineers.

**Research Proposition 2:**

Engineers who are entrepreneurs will measure significantly higher on the risk-taking orientation score than non-entrepreneurial engineers.

**Research Proposition 3:**

Engineers who are entrepreneurs will measure significantly higher on the proactiveness orientation score than non-entrepreneurial engineers.

**Research Proposition 4:**

Engineers who are entrepreneurs will measure significantly higher on the competitive aggressiveness orientation score than non-entrepreneurial engineers.

**Research Proposition 5:**

Engineers who are entrepreneurs will measure significantly higher on the autonomy orientation score than non-entrepreneurial engineers.

**Research Proposition 6:**

The five dimensions of entrepreneurial orientation combine to make a unidimensional construct.

**Research Proposition 7:**

The unidimensional EO construct of engineers who are entrepreneurs will measure significantly higher than that of non-entrepreneurial engineers.

**Research Proposition 8:**

The EO construct is multidimensional, with each dimension not being interrelated with any other.

## 3. LITERATURE

The literature review is divided into five main components: the definition of entrepreneurship; entrepreneurship as a behavioural phenomenon; entrepreneurial intention; knowledge workers; and engineers as entrepreneurs.

### 3.1 Definition of entrepreneurship

Entrepreneurship has been defined as the ability to channel creative innovations into ventures that have value, as well as the ability to create and sell new ideas and build new business ventures [26]. Madsen [29], citing Churchill (1992) and Shane & Venkataraman [23], add that entrepreneurship is about searching for opportunities and/or processes that uncover and develop opportunities. Drucker (1999), cited in Esbach [8], claims that - despite the huge interest in the subject of entrepreneurship since its inception - a definition of entrepreneurship is hard to pin down because of the different descriptions used by many authors. Whatever definition of entrepreneurship is adopted by various authors, the authors of this study agree with the essential point that entrepreneurship is about wealth creation, as advocated by Ireland *et al* (2001), cited in Wang [24].

### 3.2 Entrepreneurship as a behavioural phenomenon

Baron [2] suggests that entrepreneurs engage in generating thoughts for new ideas and products, in recognising business opportunities related to the new ideas and products, and in obtaining the resources needed for developing these ideas through to the launch of the products. The author also identifies entrepreneurs as an essential part of the process through which new ventures are created, and states that it is reasonable to suggest that at least some aspects of their behaviour and cognition play an important role in the entrepreneurial process.

Fulford & Rizzo [10] propose that entrepreneurship is a behavioural phenomenon. This supports the findings of Baron & Ward [3], cited in Pownall & Lawson [20], that entrepreneurs, when compared with non-entrepreneurs, show behavioural differences as a result of cognitive differences resulting from factors with which they interact in the environment. Baron [2] adds that entrepreneurship researchers should focus primarily on entrepreneurs' behaviour and cognitive variables and/or processes that are closely related to the conception, launch, development, and operation of new ventures. The author also indicates that EO represents how the entrepreneur behaves towards and thinks about entrepreneurship.

Domke-Damonte *et al* [6] claim that entrepreneurial activity in a particular society shapes the future pursuit of the activity by individuals within that society. This is supported by Begley & Tan (2001), cited in Pownall & Lawson [20], who state that the perception of a cultural-level connection between innovation and successful entrepreneurship may actually dampen an individual's desire to start a business if this desire is not supported or evidenced by influential members of that society who question the desirability of becoming an entrepreneur.

Pownall & Lawson [20] add that the availability of successful entrepreneurial role models in the individual's environment will encourage successful entrepreneurial decision-making. Among many other additional factors, Domke-Damonte *et al* [6] state that the social setting as a whole - such as community, government agencies, financial resources, and family issues - forms part of an integral national culture that is a contributing factor towards individuals' EO. The above theory underpins the argument of Litan & Song [14], who conclude that it is important for entrepreneurs in different parts of the world to shape their entrepreneurial activities to adapt, among many factors, to laws, cultures, and forces that drive entrepreneurial success in their context.

Krauss *et al* [12] show evidence, however, that the EO behaviour pattern should be found to be common in entrepreneurs. Pownall & Lawson [20] confirm that the EO of an individual can be understood to result from a mix of personal and situational factors. Additionally, Fulford & Rizzo [10], citing Aloulou & Fayolle [1], state that EO is a form of strategic orientation in which entrepreneurship becomes the dominant logic.

Entrepreneurial Orientation (EO) is generally defined as the processes, practices, and decision-making activities that lead to new start-ups. Lumpkin & Dess [16], cited in Domke-Damonte *et al* [6], state that EO involves the intentions and actions of key players functioning in a dynamic process with the aim of creating new ventures. Rauch *et al* [21] agree that EO represents the policies and practices that provide a basis for entrepreneurship. These authors add that EO has its roots in the body of knowledge on the strategy-making process. It is viewed as the entrepreneurial strategy-making processes that key decision-makers use to enact their business's organisational purpose, sustain its vision, and create a competitive advantage.

Domke-Damonte *et al* [6] cite Grant & Bush (1995) and West *et al* [25], who claim that EO provides insight into the predispositions that an individual may carry into a business setting. These authors explain that EO provides an indicator of the requisite behavioural initiatives that are conducive to new-venture development. Miller (1983), cited in Li *et al* [13], originally characterised EO by three dimensions: innovativeness, risk-taking, and pro-

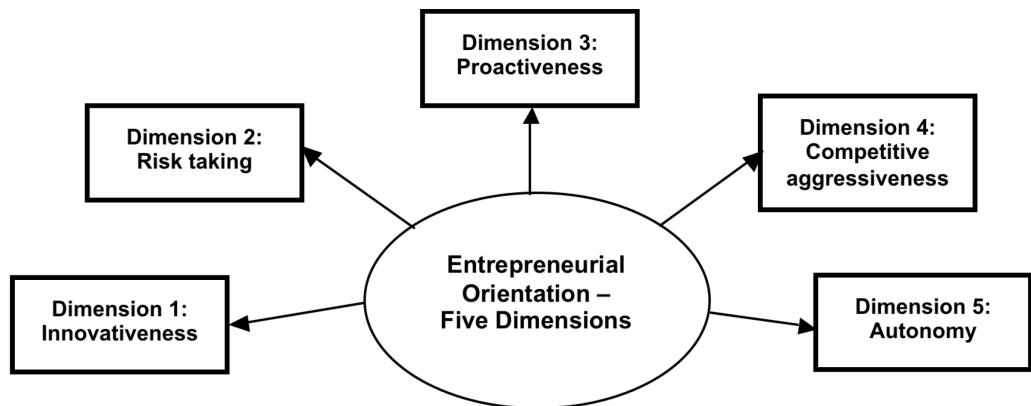
activeness. Morris & Paul (1987), cited in Li *et al* [13], are among the authors who retain the three dimensions of EO as a construct. Lumpkin & Dess [16] refer to Tan (1996) and Miller (1983), who have associated these dimensions with the promotion of technological innovation and performance within firms. Lumpkin & Dess [16], cited in Rauch *et al* [21], suggest that two additional dimensions - competitive aggressiveness and autonomy - be added to the EO construct.

Citing Miller (1983) and Lumpkin & Dess [16], Domke-Damonte *et al* [6] sum up all the previous research findings and claim that EO is characterised by five dimensions: the propensity to act autonomously (autonomy); the willingness to innovate (innovativeness) and to take risks (risk-taking); a tendency to be aggressive towards competitors (competitive aggressiveness); and being proactive about market opportunities (proactiveness).

In conclusion, the study aligns itself with Miller (1983) and Slater & Narver (1995), cited in Zhou *et al* [28], that EO is the key to initiating innovative activities; hence it is a major construct for the study of entrepreneurship. This research, as mentioned earlier, is focused on studying and comparing the EO of entrepreneurial and non-entrepreneurial engineers.

Although many authors have been quoted as saying that EO is a unidimensional construct, other EO studies have supported the idea that EO is a multidimensional construct [16, 5, 21]. As part of this research, the study also tested whether EO should be considered a unidimensional or a multidimensional construct.

The following section explores the intention of engineers to be entrepreneurs, relating it to the presence of an ideal EO necessary to enter entrepreneurship.



**Figure 1: Dimensions of EO**

*Source: Self-compiled, adopted from supporting literature on EO*

### 3.3 Entrepreneurial Intention (EI)

Domke-Damonte *et al* [6] mention that entrepreneurial intention is the precursor to entrepreneurial activity, as entrepreneurial interest must exist before a business can be started. Pownall & Lawson [20] argue that individuals will become entrepreneurial if they recognise both the desirability and feasibility of new venture creation or development. In view of the above findings, and in relation to this study, the author therefore infers that engineers - even those with a high EO - may not enter entrepreneurship unless there is an entrepreneurial intention to do so.

Pownall & Lawson [20] point out that EO is a mix of both situational and individual factors. The authors, citing Baron & Ward [3], add that Entrepreneurial Intention (EI) is developed

from cognitive viewpoints. The relevance of cognitive science to the study of entrepreneurship has suggested that entrepreneurs (when compared with non-entrepreneurs) may differ in their knowledge (the sum of what they know), in how they interact with their environment (recognising what is a valid information source and what may constitute a previously unidentified opportunity), and in their probable greater use of heuristics as satisfactory decision-making mechanisms.

Pownall & Lawson [20] endorse the above views by stating that there is a clear relationship between cognition of the desirability and feasibility of a venture, and the environment within which the individual is active. The research findings suggest that two engineers with different cognitive viewpoints will act differently towards an opportunity, even though it manifests itself to both individuals in the same way. Moreover, the cognitive viewpoint that enables one engineer to enter the entrepreneurial process and the other not to do so can be attributed to situational factors. This is in line with the findings of the previous section, which identified EO as a situational factor influenced by the environment in which the individual is active.

The literature covered so far has contended that EO is context specific and is shaped by the situational factors in a specific environment. The following section seeks to highlight the specific factors that will be included in this study in fulfilment of the secondary objectives of this research. Situational factors refer to elements of culture, work experience, education, and the environment, created by institutions and government agencies that contribute to the promotion or hindrance of entrepreneurship in a national economy.

### 3.4 Knowledge workers

To create a context for investigating the importance of knowledge workers in entrepreneurship, this section revisits the definition of entrepreneurship, based on findings that knowledge about identifying opportunities in a specific market is of key importance. As mentioned above, entrepreneurship has been defined as the ability to channel creative innovation into ventures that have value, as well as the ability to create and sell new ideas and build new businesses [26]. Building on this, Baron [2] and Aloulou & Fayolle [1] have suggested that some entrepreneurs' activities include identifying the resources necessary to develop ideas to launch new products and services. A review of the study by West *et al* [25], citing Green & Brown (1997), suggests that, in line with resource-based theory, five resources - human, social, physical, organisational, and financial - need to be acquired to enable entrepreneurship. Knowledge or intellectual property components of the five resources have been identified as the most critical for new entrepreneurial ventures.

Carlaw *et al* [4] have argued that the world population has become a knowledge society or economy that requires the use of knowledge to advance innovation. In a knowledge society, a knowledge worker is defined as someone who both has a formal education and practical experience, and uses knowledge as the base needed to compete and innovate [8]. Dutiro [7], citing Drucker (1985), acknowledges that innovation is an instrument that entrepreneurs use to exploit shifts in the economy. In addition, entrepreneurial innovations are instrumental in the birth of a Kondratieff Spring, which denotes a period of economic growth. Drucker's (1985) view is supported by Draper (2009), also cited in Dutiro [7], who asserts that through innovation, entrepreneurs and technologists could bring about economic recovery.

It is apparent that entrepreneurs who wish to be successful should possess knowledge or intellectual property that helps them to recognise and exploit opportunities in a specific environment, and they should possess a high EO and EI. This is supported by West *et al* [25], citing Malecki (1997) and Wiklund & Shepherd (2003), who suggest that knowledge resources are complex and encompass the 'know-how' and the 'know-what' related to a specific skill that is needed to identify opportunities in a specific market. Furthermore, West *et al* [25], citing Wright *et al* (1997), affirm that the 'know-how' and 'know-what' are related to markets and innovation capabilities, which are dimensions of starting up new ventures. West *et al* [25] add that technological resources that encompass intellectual

property rights have become important to entrepreneurship. They cite Venkataranan's (2004) observation that science-based and technology-based new ventures constitute an important economic development effort. Moreover, Wu *et al* [27] have found that EO can enhance the relationship between knowledge-based resources and a firm's performance, as innovation involves the combination of assets, and that EO may facilitate the ability to discern and combine appropriate resources to enable innovation.

### 3.5 Engineers as entrepreneurs

Engineers form part of the knowledge economy by virtue of having been formally educated and possessing specific experience in their application of engineering knowledge. Innovation in the knowledge economy is driven by the combination and recombination of existing and new knowledge. It therefore clear that engineers with the correct EO have the ability to use their current technical knowledge to contribute to the innovation space, and so to advance economic growth through entrepreneurship. This aligns with the theory of Zhou *et al* [28] that EO highlights the spirit of creating new business out of on-going practices.

The idea that engineers have the unique capability to contribute to economic growth through entrepreneurship is supported by the finding of Baron [2]. This is that some people recognise opportunities that others may not perceive, because they have better access to information, associated with factors such as being in that particular market. This finding does not necessarily mean that non-engineering individuals will fail to realise engineering opportunities; but it does suggest that engineers may be more likely to grasp engineering opportunities as they better understand the market, the customers, and the gap created by the current market offering. As we have seen, Coetzer (2006) in Esbach [8] suggests that engineers, with their innovation-channelling skills, create products and processes that add tremendous value to products in the market environment.

## 4. RESEARCH DESIGN

The measuring instrument consists of three sections: the demographics, the EO dimensions, and situational factors. In addition to the three original EO dimensions, two dimensions - competitive aggressiveness and autonomy - were found to form part of the EO construct by Lumpkin & Dess [15] and Lumpkin & Dess [16] respectively. The overall result was a five-dimension 18-item EO scale. The Lumpkin & Dess [15] study using the five-dimension 18-item EO construct scale indicated that the content was adequate for measuring the five-dimension EO construct. However, it was highlighted that the autonomy dimension should be included with the other four dimensions in tests of discriminant and concurrent validity, in order to refine the measurement tool.

A descriptive, quantitative research study was conducted to characterise the entrepreneurial orientation of engineers within South Africa, and to assess the situational factors that hindered or promoted entrepreneurial entry by both groups of engineers. Establishing the general interest in entering entrepreneurship by non-entrepreneurial engineers was also carried out. A non-probability snowball sampling technique was applied to increase the number of responses, particularly from the entrepreneurial engineers. The original and standardised EO scale of Covin & Slevin (as suggested in Kreiser *et al* [30]) incorporating the dimensions of Lumpkin *et al.* [15] into a five-dimension EO scale has been found to be valid and reliable in various research and cultural settings. The authors deemed this scale to be appropriate for this research.

The research instrument consisted of a five-dimension 18-item questionnaire incorporating the original EO scale. The EO scale features a 7-point Likert scale where '1' indicates strong agreement with the statement on the left side of the Likert scale. Selecting '7' indicates a strong agreement with the statement on the right side of the Likert scale.

## 5. DISCUSSION OF RESULTS

The main objective was to study the EO of engineers, using eight propositions. The secondary objective was to understand the situational factors that have contributed to engineers' business entry (or lack of it) into entrepreneurship. The results of the EO research propositions are discussed first, followed by a discussion of the situational factors. The concluding remarks present an integrated view of the EO and situational factor results.

### 5.1 Demographic analysis and situational factors

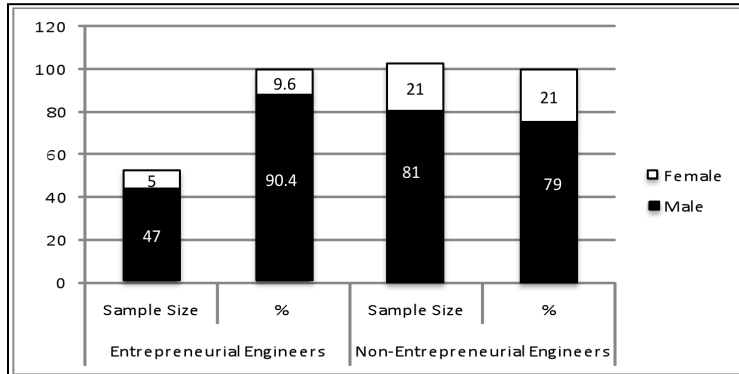


Figure 2: Percentage and frequency distribution of respondents' gender

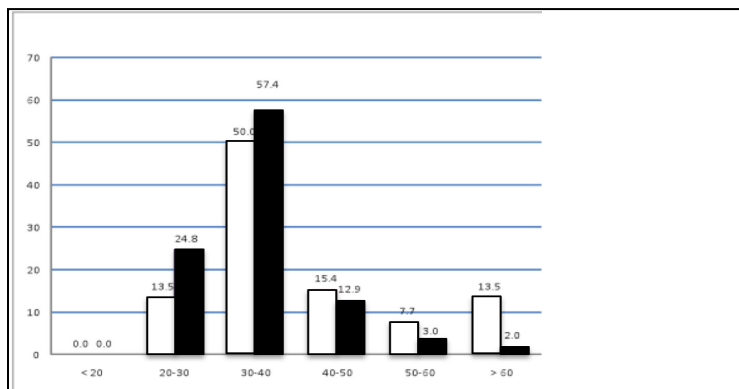


Figure 3: Percentage distribution of respondents' age

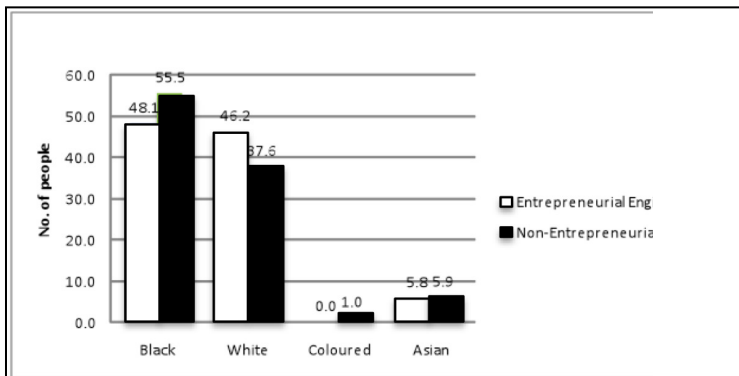


Figure 4: Percentage distribution of respondents' race



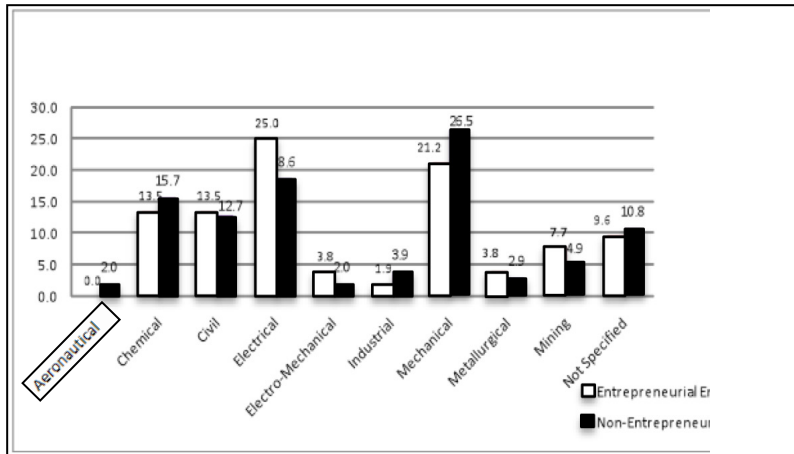


Figure 5: Percentage distribution of respondents' engineering qualifications

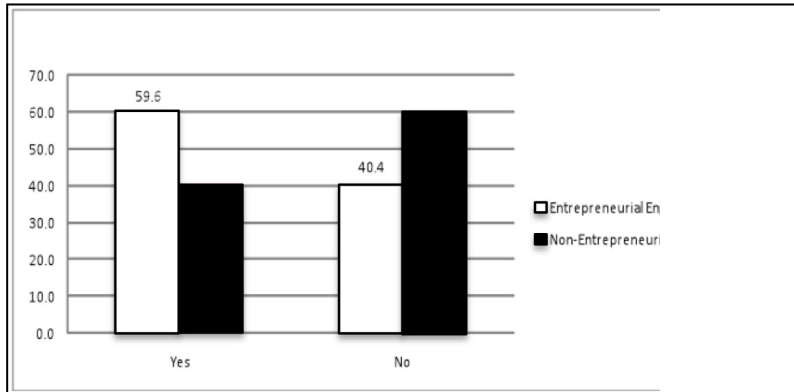


Figure 6: Percentage distribution of respondents' business management related qualifications

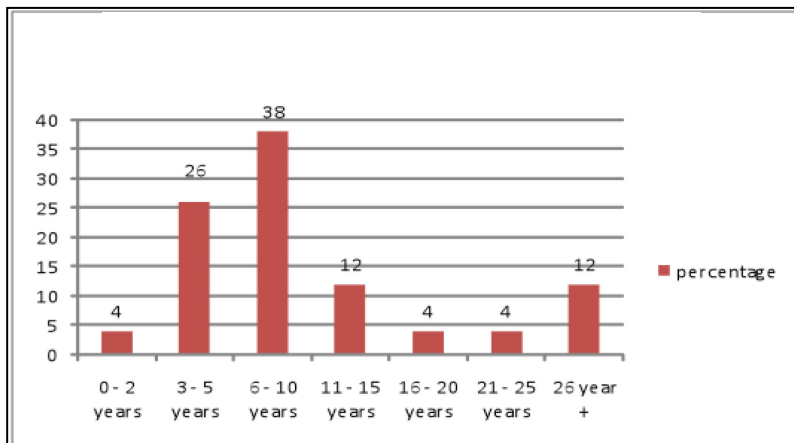


Figure 7: Years of employment before start-up

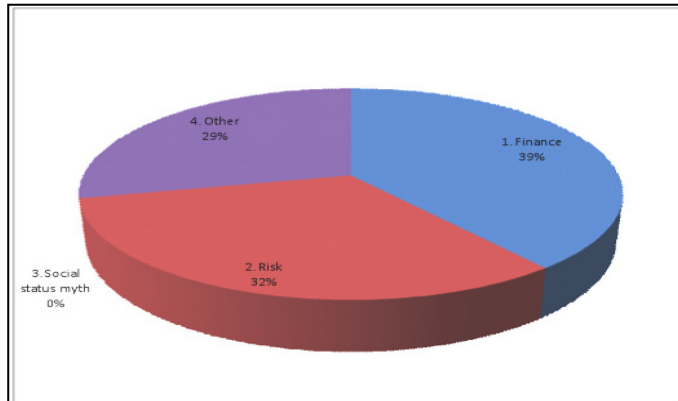


Figure 8: Percentage distribution of factors that hinder entrepreneurial entry

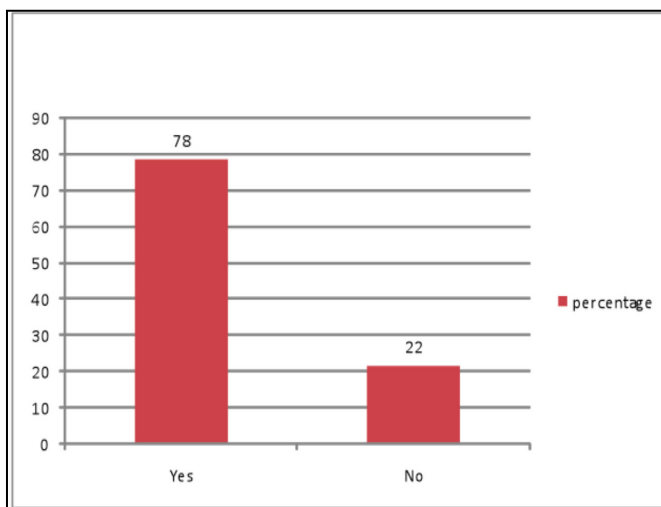


Figure 9: Percentage distribution of future plans to start a business

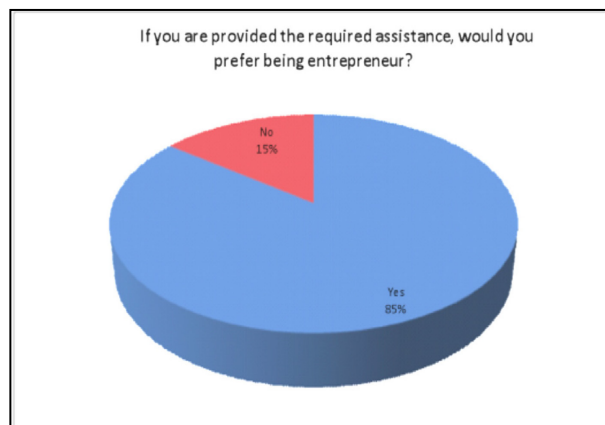


Figure 10: Percentage distribution of preference of non-entrepreneurs to become entrepreneurs

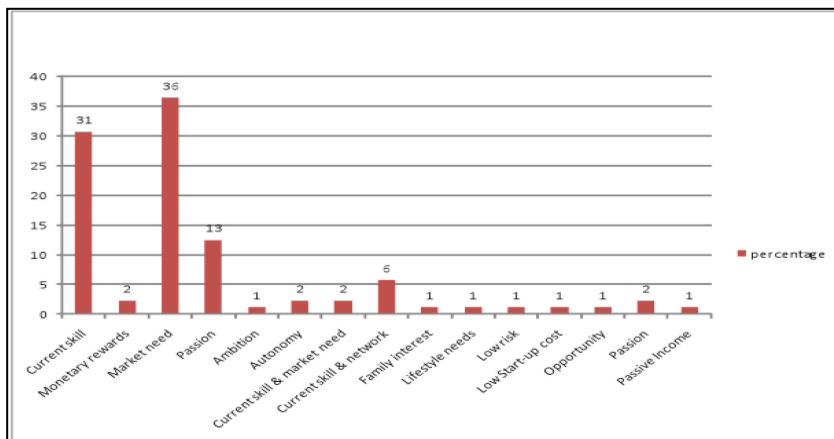


Figure 11: Percentage distribution of preferred industries in which to start a business

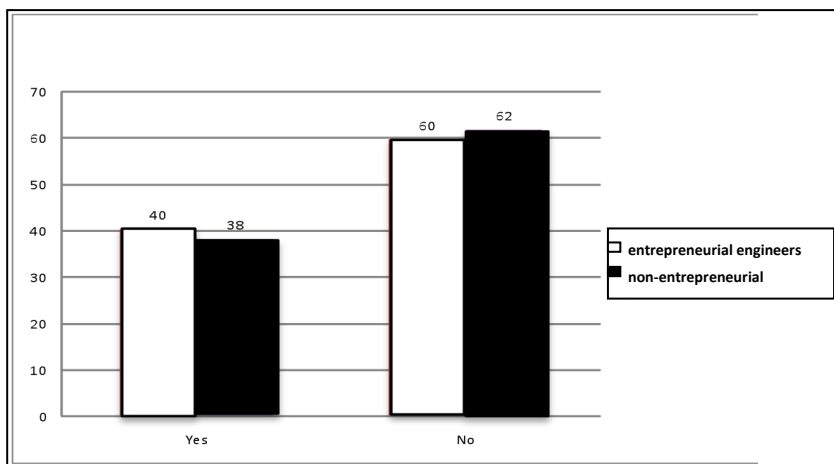


Figure 12: Percentage distribution on whether an engineering degree develops entrepreneurial skills

## 5.2 Research propositions

5.2.1 **Research Proposition 1:** Entrepreneurial engineers will measure significantly higher on the innovativeness orientation score than non-entrepreneurial engineers.

The t-test procedure: means, standard deviation, error, and P-value						
Dimension	Group	N	Mean	Std Dev	Std Err	Pr >  t
Innovativeness	ENT	52	4.5192	1.0053	0.1394	0.7825
	NONENT	102	4.4725	0.9585	0.0949	
	Diff (1-2)		0.0467	0.9744	0.166	
*Denotes that mean difference is significant at 5% confidence level						

Table 1: t-test Innovativeness

The descriptive statistics presented in the results section show that the entrepreneurial engineers had a higher mean innovativeness score of 4.52 compared with the 4.47 score achieved by their non-entrepreneurial counterparts. The t-tests, however, confirmed that the mean score difference between the two groups was not statistically significant at a 5% confidence level. This finding is contrary to the literature and to the research proposition that the entrepreneurial engineers would measure a significantly higher score than their non-entrepreneurial counterparts. Although it was acknowledged that the innovativeness scale was found to be reliable, the research proposal was not supported, as the mean difference between the two groups' innovativeness scores was found not to be statistically significant. Research proposition 1 was therefore rejected.

**5.2.2 Research Proposition 2:** Entrepreneurial engineers will measure significantly higher on the risk-taking orientation score than non-entrepreneurial engineers.

The t-test procedure: means, standard deviation, error, and P-value						
Dimension	Group	N	Mean	Std Dev	Std Err	Pr>  t
Risk Taking	ENT	52	4.3798	1.0067	0.1396	0.0073*
	NONENT	102	3.9069	1.028	0.1018	
	Diff (1-2)		0.4729	1.0209	0.174	
*Denotes that mean difference is significant at 5% confidence level						

**Table 2: t-test Risk-taking**

This result shows that the entrepreneurial engineers had a higher mean risk-taking orientation score of 4.3 compared with the 3.9 score achieved by their non-entrepreneurial counterparts. The t-tests confirmed that the mean score difference between the two groups was statistically significant at the 5% confidence level. This finding is supportive of the literature and the research proposition. The research proposition stating that entrepreneurial engineers would measure a significantly higher risk-taking orientation score than non-entrepreneurial engineers was supported by the findings of this research. Research proposition 2 was therefore accepted.

**5.2.3 Research Proposition 3:** Entrepreneurial engineers will measure significantly higher on the pro-activeness orientation score than non-entrepreneurial engineers.

The t-test procedure: means, standard deviation, error, and P-value						
Dimension	Group	N	Mean	Std Dev	Std Err	Pr>  t
Proactiveness	ENT	52	5.1349	0.9516	0.132	0.0327*
	NONENT	102	4.7721	1.0449	0.1035	
	Diff (1-2)		0.3626	1.0145	0.1729	
*Denotes that mean difference is significant at 5% confidence level						

**Table 3: t-test Proactiveness**

The descriptive statistics show that the entrepreneurial engineers had a higher mean proactiveness score of 5.13 compared with the 4.77 score achieved by their non-entrepreneurial counterparts. The t-tests confirmed that on this dimension, the mean score difference between the two groups was statistically significant at the 5% confidence level. The research proposition stating that entrepreneurial engineers would measure a significantly higher proactiveness orientation score than non-entrepreneurial engineers was supported by the findings of this research. Research proposition 3 was therefore accepted.

**5.2.4 Research Proposition 4:** Entrepreneurial engineers will measure significantly higher on the competitive aggressiveness orientation score than non-entrepreneurial engineers.

The <i>t</i> -test procedure: means, standard deviation, error, and P-value						
Dimension	Group	N	Mean	Std Dev	Std Err	Pr>  t
Competitive Aggressiveness	ENT	52	4.7692	1.3227	0.1834	0.4543
	NONENT	102	4.598	1.3662	0.1353	
	Diff (1-2)		0.1712	1.3518	0.2303	
*Denotes that mean difference is significant at 5% confidence level						

**Table 4: t-test Competitive aggressiveness**

The competitive aggressiveness orientation scale had only one item, so reliability testing was not necessary. The t-tests confirmed that on this dimension, the mean score difference of 0.17 at 1.35 standard deviation between the two groups was not statistically significant at the 5% confidence level. This finding was contrary to the findings of Foo and Lee [8], who found that entrepreneurial individuals had a higher competitive aggressiveness score than non-entrepreneurial or low-entrepreneurial individuals. The research proposition stating that entrepreneurial engineers would measure a significantly higher competitive aggressiveness orientation score than non-entrepreneurial engineers was not supported by the findings of this research. Research proposition 4 was rejected.

**5.2.5 Research Proposition 5:** Entrepreneurial engineers will measure significantly higher on the autonomy orientation score than non-entrepreneurial engineers.

The <i>t</i> -test procedure: means, standard deviation, error, and P-value						
Dimension	Group	N	Mean	Std Dev	Std Err	Pr>  t
Autonomy	ENT	52	4.5769	0.9821	0.1362	0.0069*
	NONENT	102	4.1225	0.9352	0.0926	
	Diff (1-2)		0.4544	0.9512	0.1621	
*Denotes that mean difference is significant at 5% confidence level						

**Table 5: t-test Autonomy**

The reliability of the scale in relation to this dimension was determined by calculating Cronbach’s Alpha values, with a Cronbach’s Alpha value of above 0.6 indicating the reliability of the scale. As tabled in the results section, a low Cronbach’s Alpha of 0.45 was obtained for the autonomy dimension, suggesting that this scale is unreliable. This unreliable result for autonomy was consistent with the findings of Lumpkin et al. [15], who concluded that although the new autonomy dimension content is adequate to measure the autonomy factor, it is necessary to perform discriminant and concurrent validity testing with the other four dimensions in order to refine it. The descriptive statistics presented in the results section showed that the entrepreneurial engineers had a higher mean autonomy score of 4.6 compared with the 4.1 score achieved by their non-entrepreneurial counterparts. The t-tests confirmed that on this dimension, the mean score difference between the two groups was statistically significant at the 5% confidence level.

Although the autonomy dimension scale was found to be unreliable, the statistically significant differences between the two groups were accepted as valid, as Foo & Lee [9] argue that low Cronbach Alphas are not a threat to significant t-test results. Foo & Lee [8] make this assertion by citing Hunter & Schmidt (1990), who argue that statistically low

Alphas attenuate the effect sizes but do not change significance levels. Furthermore, Pedhazur & Schmelkin (1990), also cited in Foo & Lee [8], argue that low reliability scales lead to the attenuation of correlation coefficients between variables, thus making it difficult to find significant correlation. Although it is acknowledged that the autonomy scale was found to be unreliable, the significantly different scores on autonomy between the two groups are considered valid in the light of the Foo & Lee [8] argument, based on Hunter & Schmidt. The research proposition stating that entrepreneurial engineers would measure a significantly higher score on the autonomy orientation than non-entrepreneurial engineers was supported by the findings of this research. Research proposition 5 was therefore accepted.

**5.2.6 Research Proposition 6:** The five dimensions of EO combine to make a unidimensional construct, or **Research Proposition 8:** The EO construct is multidimensional, with each dimension not being interrelated with any other.

The <i>t</i> -test procedure: means, standard deviation, error, and P-value						
Dimension	Group	N	Mean	Std Dev	Std Err	Pr>  t
All Five Dimensions (EO CONSTRUCT)	ENT	52	4.6517	0.6888	0.0955	0.0095*
	NONENT	102	4.3426	0.6825	0.0676	
	Diff (1-2)		0.3091	0.6846	0.1167	
*Denotes that mean difference is significant at 5% confidence level						

**Table 6: t-test All five dimensions**

Factor analysis was performed to detect whether all of the 18 items made up a unidimensional or a multidimensional EO construct. The factor loading value indicates whether or not the item makes a statistically significant contribution to a factor. Items of a factor loading of 0.3 and above were taken to make a statistically significant contribution to the EO construct. In relation to the results section, it was discovered that one risk-taking item, coded CD19, and one autonomy item, coded CD24, made a statistically insignificant contribution towards the EO construct. The Cronbach's Alpha which was calculated for the entire EO scale, including CD19 and CD24, was 0.7850. This lent strong support to the view that EO is a unidimensional construct. The findings of this research therefore support the view that EO is a unidimensional construct, in line with research proposition 6. Research proposition 6 was accepted, whereas research proposition 8 was rejected.

**5.2.7 Research Proposition 7:** The unidimensional EO construct of entrepreneurial engineers will measure significantly higher than that of non-entrepreneurial engineers.

The reliability of the scale in relation to this dimension was determined by calculating Cronbach's Alpha values, with a Cronbach's Alpha value of above 0.6 indicating the reliability of the scale. As tabled in the results section, a Cronbach's Alpha of 0.78 was obtained for the overall unidimensional EO construct, supporting the view that it is reliable. The descriptive statistics presented in the results section indicated that the entrepreneurial engineers had a higher mean unidimensional EO construct score of 4.65 compared with the 4.34 score achieved by their non-entrepreneurial counterparts. The *t*-tests confirmed that on this dimension, the mean score difference between the two groups is statistically significant at the 5% confidence level. The research proposition stating that entrepreneurial engineers will measure a significantly higher unidimensional EO construct score than non-entrepreneurial engineers was supported by the findings of this research. Research proposition 7 was therefore accepted.

## 6. CONCLUSION

The significance of this study is highlighted by the two research propositions that were rejected. It could serve as a comparative base for other professional occupational groups. Although the innovativeness scale was found to be reliable, the research proposition was not supported, as the mean difference of the two groups' innovativeness scores was found not to be statistically significant. General theory on entrepreneurial skills and traits include innovativeness as a critical component in entrepreneurial performance. This finding therefore implies that entrepreneurial engineers are not significantly more innovative than their non-entrepreneurial counterparts.

The research proposition that entrepreneurial engineers will measure a significantly higher competitive aggressiveness orientation score than non-entrepreneurial engineers was not supported by this research. Previous findings on entrepreneurial orientation recorded an intense propensity towards competitiveness, which this study found to be without significance. Further research into this could find out more about the phenomenon, and offer more explanation through deeper statistical inference.

The research proposition that entrepreneurial engineers will measure a significantly higher unidimensional EO construct score than non-entrepreneurial engineers was supported by this research.

Except for the competitive aggressiveness and innovativeness dimensions, the rest of the research propositions that entrepreneurial engineers will measure a significantly higher score than their non-entrepreneurial counterparts on each individual EO dimension (autonomy, risk-taking, and proactiveness) were supported. In addition, the 18-item five-dimension EO was found to be unidimensional. As highlighted in the body of this report, various studies have found evidence that supports a unidimensional scale, while others support a multidimensional EO construct. These contradictory findings highlight the point that various factors moderate the EO construct, and that further research needs to be carried out to identify the various contexts in which dimensionality is evident and relevant.

Chi-square test results showed that the two groups of engineers were not statistically different in relation to situational factors. Based on the literature, it was expected that entrepreneurial engineers would have different and more favourable situational factors that shaped their entrepreneurial behaviour. However, given that 78% of non-entrepreneurial engineers intend to become entrepreneurs, and might indeed enter into entrepreneurship, this result may not be considered.

Although the entrepreneurial engineers were expected to have more favourable situational factors than their non-entrepreneurial counterparts, this research did not confirm this; instead, they had more in common than they differed. Apart from having similar situational factors, the majority of the non-entrepreneurial group showed a strong wish to be entrepreneurial. As these two groups were found to be similar in their entrepreneurial intent and situational factors, the fact that some are already entrepreneurs, while others are not, may be attributed to entrepreneurial entry timing or to EO difference. Entrepreneurial entry timing merely means that they will probably become entrepreneurial in the future. The majority of the non-entrepreneurial engineers have indicated that, given the assistance they need, such as financial resources (their biggest need), or legal and educational resources, they will become entrepreneurs. In the view of Domke-Damonte *et al* [6], the need for resources to becoming an entrepreneur cannot be emphasized enough. They argue that the availability of financial resources and government agencies in a social setting contributes to an individual's decision to become an entrepreneur. A lack of such resources would have serious implications for entrepreneurship, given that low-wealth potential entrepreneurs may be unable to start an entrepreneurial venture (Minniti & Levesque [19], citing Evans & Jovanovic (1989)). This may explain why some engineers are entrepreneurs, while others - regardless of the findings that they are similar in intent and situational factors - are still professional employees. This view is supported by West *et al*

[25], who found that, although knowledge resources (that is, both groups having engineering qualifications) may be a contributing factor towards entrepreneurship, it is only effective in the presence of an entrepreneurial orientation. Knowledge resources are not only academic qualifications and experience, but include 'know-how' and 'know-what' related to specific skills with which to identify opportunities; and this research has shown that both groups have these resources.

The view that EO is a differentiating factor between entrepreneurs and non-entrepreneurs was not only confirmed by the results of the EO t-testing for difference, but it was also highlighted by the situational factors. To illustrate the difference, the results presented in this study showed that 92% of non-entrepreneurs indicated that they required financial assistance to start a business, while 63% of the entrepreneurs who had started a business did not get financial assistance. It is assumed that this last group might well have required financial assistance; but the fact that 63% of them started a business without financial assistance highlights the difference between the two groups, given the same entrepreneurship cooperative environmental constraint. Carlaw *et al* [4] have highlighted that the current era is a knowledge economy, in which knowledge is the basis of innovation and competitiveness.

The need to invest in human capital - particularly entrepreneurship education - cannot be emphasised enough, considering that human capital creates economic growth through knowledge spillovers (Acs *et al* (2004 and 2005) cited in Minniti & Levesque [19]). One of the key findings was that the majority of the respondents indicated that engineering qualifications do not deliver entrepreneurial skills, and that entrepreneurship modules should be introduced into the curriculum. These findings echo the sentiments contained in Maas and Herrington [18] which identified education and training in general as the single most crucial factor hindering entrepreneurship in South Africa. Esbach [8], citing the GEM report (2006), also argues that, in general, potential entrepreneurs in South Africa lack the mindset and skills to become true entrepreneurs. They also found that engineering students in South Africa lack these skills. To improve entrepreneurial activity among engineering graduates, various universities worldwide have already incorporated entrepreneurial education into their engineering curricula (Wood *et al* [26]; Justa *et al* [11]). Overall, the situational factors highlighted the need for institutions and government agencies to play a more active role in motivating entry into entrepreneurship.

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