How Entrepreneurship Influences the Engineering Faculty at a new University of Technology

by

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Declaration

This work is submitted as full requirement for the Magister Technologiae in Electrical Engineering at Cape Peninsula University of Technology. This work had not been submitted before for any other degree at this or any other academic institution. The work is my own, original work. All sources used in this work have been referenced, using the Harvard system of in-text and end-of-text referencing.

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March 2007

Abstract

This work examines the challenges facing the Department of Electrical Engineering at CPUT regarding the development of entrepreneurship in the South Africa.

Industry and higher education in South Africa face a testing future of profound technological change, a shortage of engineers, as well as an engineering job market that continues to grow ever smaller. There is a pressing need for technology graduates to harbour skills to grow new high technology ventures.

The recent report published by the Global Entrepreneurship Monitor showed our graduates having the potential to reverse the negative growth in the skills market by way of wealth creation and thus job creation. Therefore, academic institutions, such as CPUT, need to produce not only quality technology graduates, but also effective entrepreneurial graduates.

This research examines ways in which the curriculum at the faculty could be expanded to include an engineering-biased entrepreneurship stream, presenting engineering graduates with opportunity to generate income from sources other than the job market.

The perception of both first year and BTech (fourth year) students are tested regarding the need for entrepreneurial engineers in the SA economy, and the academic's role in supporting such a need. The perception of senior staff are also sought to provide a more rounded perspective on possible interventions.

The results show both entry-level and exit-level students agree an additional stream, focusing on entrepreneurship would empower them to make informed decisions regarding their futures. The results could be used to shape the sustainable inclusion of entrepreneurial imperatives in an engineering context.

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I thank you.

Definition of Terms

- **Artisan**: A skilled technical person with limited theoretical knowledge.

- **Elitist**: A person or group of persons which enjoy exclusive rights in South Africa at the expense of the masses.

- **Higher Education Institute**: The education band offered at colleges and universities that cover further learning, beyond the secondary phase done at schools (grade 12).

- **Lifestyle entrepreneurship**: Lifestyle entrepreneurs generate sufficient income to sustain their lifestyle. These entrepreneurs do not generally generate wealth.

- **Secondary Education Institute**: The education band that include learning from grade 1 to grade 12.

- **Self-reliance**: Self employed thus independent from the dwindling job market.

- **Small business education**: The training involved in starting-up and running a small business.

List of Acronyms

BBBEE	Broad based black economic empowerment
BTech	Bachelors degree of technology
CIR	Centre for Instrumentation and Research
CITI	Cape Information Technology Initiative
CPUT	Cape Peninsula University of Technology
ECSA	Engineering Council of South Africa
GDP	Gross domestic product
GEM	Global entrepreneurship monitor
GSB	Graduate School of Business
HEI	Higher education institution
HTE	High technology entrepreneurship
LIFO	Last-in-first-out
MEC	Member of Executive Council
MIT	Massachusetts Institute of Technology
MTech	Master Degree of Technology
PK	Practical knowledge
SE	Secondary education
SEI	Secondary education institution
SETA	Services, Education and Training Authority
SME	Small Medium Enterprise
SMME	Small, Micro and Medium Enterprise
TK	Theoretical Knowledge
UCT	University of Cape Town
UK	United Kingdom

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1 Introduction

The challenges faced by Higher Education Institutions (HEI) in South Africa are complex and inter-related. The emerging South Africa economy does not have any unique challenges, but certainly has one or two unique dimensions in its portfolio. In order for one to develop strategy to promulgate change and lead an institution into the future, one needs to identify a niche or future need.

Education requires a well-balanced model when looking at the development of engineers and entrepreneurs. While it is accepted that engineering underpins the economy, it is also widely acknowledged entrepreneurship accounts for the fastest job growth figures in world economies. Hence a need for CPUT to align its strategies with that of South Africa's enabling the economy to experience rapid and sustainable growth.

In South Africa technology graduates are often flattered into believing a diploma or degree guarantees a job. This is clearly not the case as the high technology job market is diminishing. The "brain drain", where technology graduates emigrate in search of a more rewarding career, is perhaps evidence of a lack of industry capacity to attract new graduates or perhaps a disinterest of industry in what is considered as graduate incompetence.

South Africa's commitment to readdressing the imbalances of the past will imminently marginalise minority groups. Various reasons are cited for this thinking, but in reality because of restitution, the job market remains bleak for many technology graduates in South Africa.

There is a need for CPUT to restructure engineering education to focus more on the students' and academic needs. Today the official modus operandi diminishes inventiveness thus failing to provide an environment more conducive to teamwork and entrepreneurship.

With respect to education and entrepreneurship, HEIs must be proactive in the nurturing of both the technology and entrepreneurial graduates (Beyster, Freedman, Mellinger &Von Bargen, 2000).

Once we have identified the *needs* of an emerging economy such as South Africa, invariably change must occur. When looking to implement change the HEI must understand the future demand; this is simple economics. Globalisation, however, adds a spin to *simple economics* in that the world has no reference or a history of economic related activity, thus compounding the problem and forcing we as humans to develop collaborative models to provide a basis to measure success (Drucker, 2000).

In South Africa the government has been successful in laying a foundation for the advancement of entrepreneurship albeit "lifestyle entrepreneurship". Lifestyle entrepreneurship is able, however, to only just contain unemployment and improve self-esteem by instilling a sense of self worth. South Africa needs wealth creators to meet and reverse the growing unemployment problem.

Since the 1980s small, medium and micro enterprises (SMME) have taken up the challenge and have contributed significantly to the national gross domestic profit (GDP). Small business has shown its flexibility and innovation by out-maneuvering large business. Small businesses respond to opportunities because of a tacit knowledge of the local environment, seeking to meet customer needs. SMMEs generate wealth and provide jobs for those who would otherwise remain unemployed. This effectively reverses unemployment statistics.

South Africa's major industry has contributed significantly towards the GDP, especially during the apartheid era when many parastatals were established to support the state initiatives; extensive funding was made available. In this democratic dispensation, these parastatals have become barriers to entrepreneurship, becoming non-competitive and raising the barrier of entry to

markets and market share. In a country where assets and human capital is being stripped (Lacquet, 2004) it becomes imperative that we, as society, understands the need for government, industry and education to pool resources to create opportunities for wealth creation.

Global trends favour intense competition, where rapid change in industry requires a similar change in education. Technology graduates must develop skills that will present them competent to function in a global market, not just in industry. This competency is the product of theoretical knowledge (TK) gained at HEIs and practical knowledge (PK) gained in industry. Industry, together with higher education must face the profound technological challenges.

Engineers, technologists, technicians and artisans are today exposed to an industry where the number of available technical jobs is declining. The 2004 report published by PriceWaterhouseCooper (Anon. 2004) states that South Africa does well to attract foreign investment but they fail dismally in technological advancement.

Underpinned by engineers, engineering should be focused on improving the lives of ordinary people according to Ward & Angus (1996). Lacquet (2004) states that society aught to be the central focus of technological exploitation but cautions that engineering can no longer solve society's problems alone and perhaps a broader discipline is required to address the challenges of today.
Campbell (2001) is alert to the reality of integrating engineering and entrepreneurship and says that it is not an easy mix.

Mayhem and Martin (2004) found clear evidence that engineers aught to be equipped with both technical and non-technical competencies.
Lacquet supports the quest for soft skills when she says "the engineers are no longer the gatekeepers of technology advancement. The boundaries have been blurred through improved technology education of the broader society" (2004).

Students at the University of Cape Town (UCT) felt that they lacked preparation for leadership roles in industry (Lacquet, 2004).

The UCT discussion raised three important issues relating to:

1. Inadequate preparation for work in multi-disciplinary teams.
2. Little formal assessment of team participation and contribution.
3. The benefits of more team-based assignments.

Lacquet (2004) says that industry required suitably educated technical people. The challenge we face is in unifying education and presenting a diversified learnership ensuring all South Africans own South Africa. Here HEIs need to lead the charge towards demystifying the new South African landscape regarding innovation and education.

Gillin (2005) is alert to the fact that entrepreneurship education is not SMME education, a distinction often overlooked by academics. A programme to change the mindset of staff and students must be put in place to create an environment more conducive to entrepreneurship.

Certainly when government, academics and South African business pools resources a culture of entrepreneurship and technological excellence awaits. The success of this process, critical to job creation, could only be realised in an environment favourable to entrepreneurship.

South Africa has need of technology graduates to support the economy, but greater need for wealth creators to negate unemployment in SA.

The next section looks at the distinctive challenges impacting on the engineering faculty as a business in the education sector.

1.1 Institutional Challenges

There is a need for academia to adapt to a rapid changing global environment. This change imposed on education could prepare South Africans to compete in the global environment. Without exception, education emerges as the premier barrier to explosive entrepreneurial growth in the 2003 GEM survey (Orford, Wood, Fisher, Herrington & Segal 2003).

The factors inhibiting entrepreneurial growth must, in a sense, convince traditional universities to reflect on their policy regarding education outputs, especially in the light of changing student type, as legislation supports mass enrolment as opposed to previous elitist enrolment.
Technikons previously recruited industry-based students and subsequently produced quality engineers. In the new era CPUT must consider the new student type, and adopt a critical stance regarding their output production. Thus the university, at the crossroad must ask the question, "How do we adapt?"

In the light of gross uncertainty regarding the constructive impact the masses would make on industry, the university must look to position itself favourably. Such a position could include an alternate stream, geared at engineering type thinking in a SMME. This will, with the faculties' commitment to produce quality engineers, demonstrate the institution's commitment, towards entrepreneurship and the design for wealth creation.

1.1.1 Secondary Education Institutions

A contentious point on secondary education was debated on a recent television show (Anon, 2006), "Judge for Yourself", where the deputy minister of education conceded education, had not played a meaningful role in the lives of ordinary learners. This view is in sharp contrast with the views held by Ward and Angus (1996) regarding engineering and its effect on the lives of ordinary people.

The impact of a dysfunctional secondary education (SE) training system is felt at all HEI levels. The quality of SEI output is deteriorating, the morale of educators is low and learners are incapable of critical thinking. A concerted effort must be made to improve the quality of students at the exit level of SEIs.

As the character of society and industry changes so this character of education must change to educate people to meet changes.
How will HEIs improve the quality of their outputs when the inputs are clearly not competent for entry into higher education? How will the needs of South Africa be addressed when young South Africans fail to be accepted into HEIs? What is the role of the HEIs in the new education landscape?

1.1.2 Higher Education Institutions

HEIs enroll students in courses explicitly designed for industry needs and not self-reliance. While every effort is made to ensure the quality of such courses promote and sustain the relationship between the HEI and industry focus on developing ordinary people to pursue their dreams must be present.

By issuing a student an exit paper, a degree or a diploma invariably indicates the graduate is industry employable within an engineering discipline. The primary problem with this arrangement is the number of jobs available in industry to technology graduates from CPUT is dwindling, thereby significantly exacerbated unemployment statistics.

What does this mean?

The pressure to find employment is enormous. The future for the non-black graduate is bleak. This strategy is clearly directed at restoring imbalances in the national labour market. It is this challenge and others such as these that must encourage HEIs to look beyond its status quo and prepare students for other South African needs. Alternate streams will help to divert engineering graduates to service a wider spectrum of challenges South Africa needs to negotiate.

Again we ask, what does this mean? Could it be HEIs has a responsibility to ensure that in producing a graduate, such a person has a reasonable opportunity of employment?
This contentious point alerts this research to two formal questions that will help the reader to understand the climate in which this work is being researched in:

1. How the relationship between HEI – industry, impacts on unemployment?
2. Whether the quality of the student meets industry expectation?

1.2 Entrepreneurship Environment

The 2003 GEM reports (Herrington et al, 2003) education being the main barrier to progressive entrepreneurial growth. Academia must adapt to a rapidly changing global environment. At CPUT, the engineering faculty needs to recognize the benefits entrepreneurship presents graduates. Not only does entrepreneurship provide the graduates with an opportunity for wealth creation and self reliance, it furthermore prepares engineers to look at the world from both a technical as well as a non-technical perspective.

As depicted in figure 1 below, HEIs are responsible for educating South Africans. Here HEIs must balance the demands from industry, government and SEIs. CPUT will do well to take cognizance of a changing global market leading to changes in the local market. South Africa needs engineers and entrepreneurs.

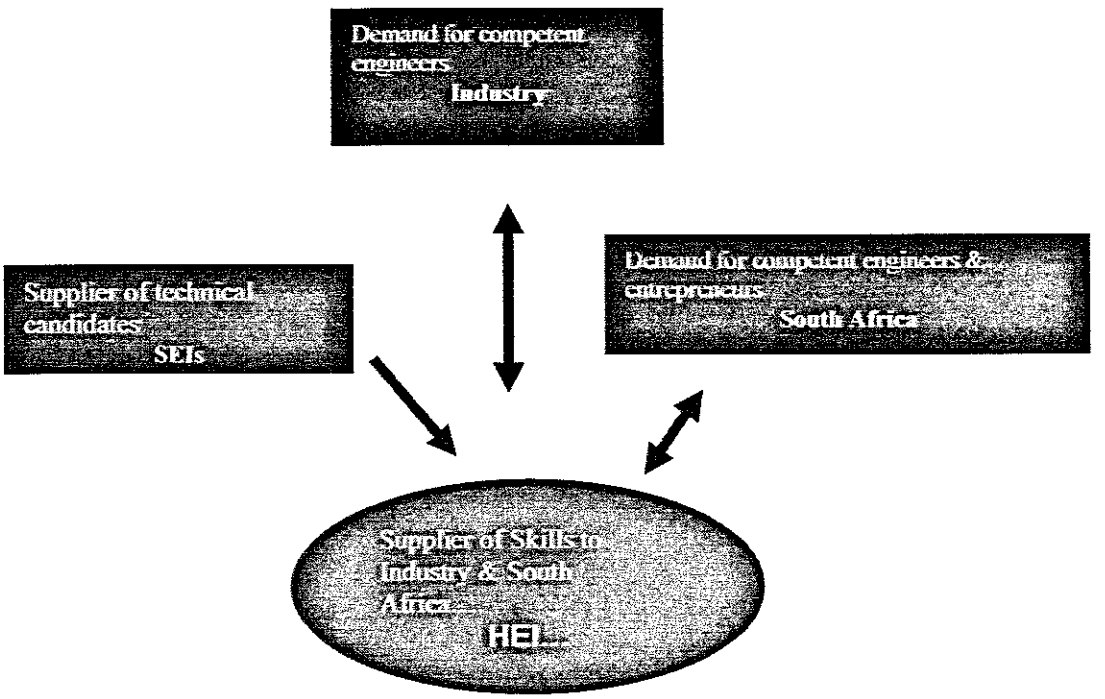

Figure 1: The role of the HEIs

Engineers worldwide will continue to support the local economies. However, in an economy with 40% unemployment, a new strategy is required. South Africa desperately needs entrepreneurs to reverse the unemployment problem irrespective whether academics feel that entrepreneurship has no place in the engineering faculty.

The literature review will show that entrepreneurship requires an appropriate environment. The authors introduce the point that engineers are trained in an engineering environment and entrepreneurs must be trained in an entrepreneurial environment. The factors inhibiting entrepreneurial growth must be addressed expediently, in a sense, persuade traditional universities to reflect on their policy regarding education output, especially in the light of changing student type, where legislation imposes mass enrolment as opposed to elitist enrolment.

If HEIs are to address the problems South Africa faces, then HEIs must undertake to produce engineering specialist graduates as well as engineering entrepreneurial graduates. Thus, in addressing the needs of the high technology job market, producing engineers and entrepreneurs appears to be the responsibility of HEIs more than industry or government as depicted in figure 2.

While HEIs provide TK to both the engineer and the entrepreneur, the choice for entrepreneurship or engineering must be seated with the student. But how different are the two disciplines?

1.2.1 Distinction: Entrepreneur and SMME

The entrepreneur is central to both SMME and entrepreneurship, and continues to play a pivotal role in meeting the South African requirements.
The 'introduction' highlighted the need for South Africa to view engineering and entrepreneurship as potential entities with a potential to drive the South African economy collectively or individually.

Figure 2, depicts the contribution that both engineers and entrepreneurs to the SA economy. If the entrepreneur is key to the entrepreneurship process (Bygrave, 1989a), what about the engineering process?

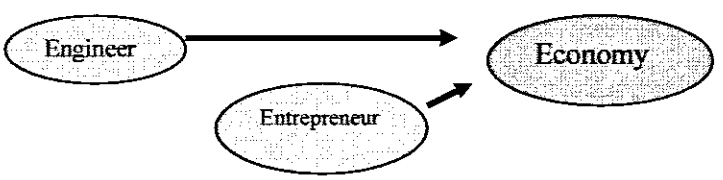

Figure 2: Engineers and Entrepreneurs drive Economy

The collaboration between industry, government and HEIs is essential when looking to build a new sustainable economy. However, such collaboration might not be high on the industry's priority list; the perception is that graduates gain PK only to compete with industry at some later stage.

One reason for this misperception is failing to make a distinction between SMMEs and entrepreneurship. A further distinction should be made between entrepreneurship and SMME education.

Entrepreneurship in simple terms, according to Gillin (2005), is a people-centric exercise, while the SMME is customer-centric; there is a subtle difference in centricity but a definite link between business and SMMEs.

Gillin (2005) suggests the failure to distinguish entrepreneurship education from small-business education could be a typical reason why industry frowns on a collaborative endeavour with government and HEIs.

SMMEs take technology to the market much like established industries. SMMEs (engineer) are customer-centric (Gillin, 2005) therefore responding to the questions of "what" and "when" it has to undertake the tangible element. Entrepreneurship is the thought patterning required, manipulating technology, recreating new products and creating entire industries. It responds to the question of "how" and "why" it has to do with non-tangible elements.

The next section discusses entrepreneurship and the perceptions of students measured during 2004. This undergraduate project provides a useful base to understand the changing perception regarding entrepreneurship.

1.2.2 Entrepreneur

Graduates are trained to solve industry problems. The difficulty is such graduates are insufficiently skilled to maneuver in a rapidly changing technological - business environment. According to Esbach & Campbell (2004), the inadequate exposure to entrepreneurship education sets the postgraduate at a disadvantage when competing for a job market position or for future market share with a venture.

What these potential entrepreneurs require is a platform to convert raw desire and ability into a SMME output.

Entrepreneurship education is a life-long learning experience requiring a culture of thought, a favourable environment and a desire to build a sustainable venture. As in jazz where an unstructured sequence captures the imagination of the audience, it is the ability of the performer to continually subject the audience to the unknown; it is the majestic arrangement of disorder that grips the imagination.

Is the improvisation unstructured? Is the arrangement disorderly? The audience seeks the next big event and subjects itself to some form of pre-event enthusiasm that leads to some level of expectation. In reality the composition is a collection of phenomena (Bygrave, 1989a), designed by the artist continuously, that allows for quick reference and analysis, enabling the brain (the artist's and the audience's) to recognise a complex pattern (De Bono, 1992).

While both parties enjoy the results, it really is the amount of effort employed by the artiste in rearranging the music that differentiates between him or her and the audience.
Similarly, in entrepreneurship, it is the ability of an entrepreneur to visualise what others cannot imagine because the brain has become adept at developing a complex pattern.

Hindle and Rushworth (2000) show entrepreneurship education is an issue of worldwide economic and social significance and at a macro level entrepreneurship curriculum development should be regarded as a core element, not an optional extra.

Placing these metaphors in perspective this research reasons that as in jazz, entrepreneurship relies on complex pattern recognition to make sense of the chaos. To this end, Hindle and Rushworth (2000) suggest entrepreneurship education is pivotal, in helping engineers to better relate to entrepreneurship and chaos using pattern recognition.

This work makes the following distinction:

1. Not all engineers are entrepreneurs, but accept that engineers could be sensitised regarding entrepreneurship.
2. Entrepreneurship does not alter contempory knowledge of the engineer, but rather it builds on existing knowledge.

Engineers and entrepreneurs are different sides to the same coin.

Having seen the importance of entrepreneurship education, the research must explore the perceived value of the SMME *as a wealth creator*. This is looked at in the next section.

1.2.3 SMME

Dr Eltie Links (2002), executive head: corporate citizenship, SANTAM LTD says even though South Africa has made tremendous economic strides, the benefits of progress are not yet manifested equitably. He says the role of the SMME sector in this development process is beyond dispute worldwide. SMMEs have delivered consistent results (wealth creation, jobs, and fulfilled lives) in providing opportunity in almost all sectors of the economy. Although he expands on the strides made by SMMEs, this research ponders to reflect on the imbalances within the high technology sector.

The president of South Africa has called for greater effort to establish the SMME sector, this is also evident in the Small Business Development Amendment Act (South Africa 2003). According to the 2003 GEM report, the government must relax policy and make funding accessible to entrepreneurs. Furthermore, the government needs to support entrepreneurial education at HEIs and SEIs.

Minister Ebrahim Rasool (2002), the premier of the Western Cape Province, continues to build on this call for engagements when he says SMMEs are a vehicle to ensure that ordinary citizens, through the application of their entrepreneurial skills, are able to make a living in spite of a generally hostile global economy.

He says that SMMEs are a generic response to global economic trends, as well as a SA drive for equity through job creation and empowerment.

He insists the SMME will be faced with a few hurdles and this research assumes one such hurdle could be constructive education within the high technology sector. Another such hurdle must be the limited focus of engineering graduates on wealth creation.

According to Gillin (2005), entrepreneurship is an enabling tool to allow persons of any discipline to actively contribute to people-centric industry. Hindle and Rushworth (2000), support the view that the national education framework should design an alternative stream (technology innovation) within the engineering discipline to recognise and facilitate the learnership of high technology entrepreneurs.

The small business failure rate is still too high and various reasons are cited. The concern of this research lies in the education realm referencing the 2003 GEM report (Herrington et al, 2003). While government is looking to benefit from SMME activity and appears committed to facilitating the process, the HEI must respond to the GEM report that clearly highlights the education problem in academia.

SMME activity is pivotal to South African economic reform and SMME education would be geared to address the dynamics of business? How does the entrepreneur contribute to the economy?

1.3 Engineering Entrepreneurship

At this point I will not attempt to define the entrepreneur, but continue to examine the environment in which the entrepreneur operates from a competitor's perspective.

1.3.1 Engineering Entrepreneur

A common understanding among students and industry is that all entrepreneurs use a certain code when looking at business. This is not the case, students look at entrepreneurship from different perspectives and expect different outcomes. When the question is asked, "What is entrepreneurship?" most people would know. The issue at hand is whether people can define entrepreneurship (Frey, 2004).

According to Schumpeter (1934) [1], the entrepreneur innovates products, development methods, new markets and forms new organisations; illuminating the wealth creation potential in an engineering environment.

Emerging entrepreneurial growth companies generate the majority of new jobs and innovations in economies globally (Beyster et al, 2002).
Technology based companies in particular, create up to 11 spin-off jobs per employee in a new venture (Campbell, 2001).

The 2003 GEM report state the amount of start up companies within the South African environment is not good. This research looks at this phenomenon in light of the education framework to establish the underlying factors. Within the world context, South Africa would begin to make an impact on the world market if entrepreneurship was held in high esteem. Entrepreneurship must be taken seriously at all levels of education, from SEI to HEI and beyond.

[1] Schumpeter (1934), cited by quickmba (2007)

Entrepreneurship is critical to technological development; a fact is well understood by the famous MIT School of Engineering and Technology Management.

"The MIT Entrepreneurship Centre is committed to fostering and developing MIT's entrepreneurial activity; this area of engineering is vitally important" (Anon ,2003).

Following informal discussion the research is led to examine whether engineers develop novel technology or whether engineers are becoming more involved in technology manipulation and redesign. Academics are seeking to find avenues to develop programmes that support both engineering development as well as technological development.

Fundamentally, the distinction between SMME and entrepreneurship is pivotal to the understanding the dynamics of engineering and technology manipulation.

Entrepreneurs not only create jobs, new products and services, but their companies have a huge effect on the international market and contribute to the local GDP. Research shows that the country's entrepreneurial capacity correlates to the economic prosperity of the nation. According to Babson College and London School of Business, entrepreneurial activity could account for one third of economic growth (Beyster et al, 2002).

1.3.2 Engineering Industry

If the entrepreneur is to generate the same or more jobs than industry and also if the entrepreneur (SMME) creates the same or more wealth than industry, then it is apparent there are two paths a graduate may take to contribute to the South African economy as shown in Figure 3.

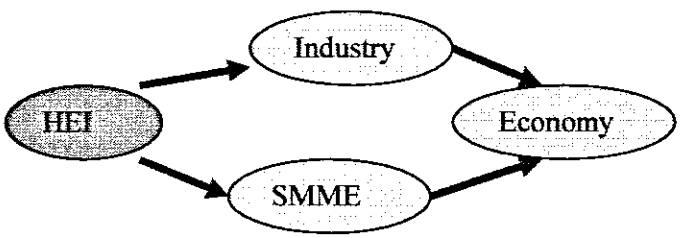

Figure 3: The two paths to the SA economy (Esbach & Campbell, 2004)

At CPUT, the engineering focus is on industry and the role engineers play as employees. To this end engineers are specialised and thus narrowly focused on product development. The engineering faculty has a culture of preparing its graduates to function competently in industry. Academics have highlighted the fact that industry in itself self-indulgent hence a need from time to time for HEIs to push new thinking into industry.

In trying to understand the phenomenon named "industry", the research set out by asking the question, "Who is industry?" then "what is industry?"

There would be no clear-cut answer. Within the technology environment industry would be any company that deals with technology related products.

For the purpose of understanding the task facing entrepreneurs and moreover, to understand the GEM view regarding the age of entrepreneurs, the research needed a clear definition of the "industry".

In the real world, students are trained to develop technology and HEIs do well to ensure this progress. In the practical world more is expected from technology graduates than mere technological development. Research by Lacquet (2004) showed practitioners required people skills to enable them to work with in teams or as team leaders. CPUT technology graduates, trained to support industry, must be continually educated to deal with an industry constantly changing to adapt to market demands.

Such change is ably underpinned by strong engineering education without regard for entrepreneurship or any creative science. The distinction Hindle and Rushworth (2000) so aptly make, must lead the reader to recognise the difference between SMME and entrepreneurship education.

Industry is not truly concerned about entrepreneurship and its frills. Industry is about profits and in reality industry does re-engineer, restructure or retrench people from different disciplines including technology graduates, to maximise share value or profits.

Industry is also selective regarding skills. In its quest for excellence, industry simply chooses the best technology graduates and appoints them at a competitive salary. Industry requires engineers with strong technology skills.
HEIs must take an entrepreneurial approach and look beyond the "now" and develop plans to counter the negative sentiment of unemployment. One such alternative is to prepare students for self-reliance.

In trying to understand industry clear evidence of a complex interwoven arrangement of corporate activity is found that seems to be designed to nullify competition. Often these industries were international and continued to network effectively, expanding boundaries and defining corporate brand.
With a typical conglomerate registering in excess of 4 000 various patents, it testifies to the extent of its product development capability.

A plethora of magazines bears testimony to the well-polished disciplines that dictate technological advancement and product progress. How does the entrepreneur manoeuvre within this environment where industry is clearly unresponsive? How will the entrepreneur progress from conceptualisation to commercialisation unless he markets his product to industry?

In the high technology environment the industry controls the gateways to the markets through networks and associations. Entrepreneurs will do well to associate with forums consisting of networks of like-minded entrepreneurs seeking to build capacity and a market presence.

1.3.3 Engineering Student

To correct past skills imbalances, the government is saying all learners should have access to HEIs. This legislation presents new challenges to HEIs. Learners, having been victimised by an unstable school education system are not competent to deal with HEIs in their existing form.

The learners have embraced the opportunities to:

1. Further education
2. Greater access to jobs
3. Improve self-esteem and competency

The research has embarked on a new trend of thought and is looking at a social behaviour variable, namely 'discipline'. The research infers discipline has deteriorated since 1986 when corporal punishment was banned from schools.

Apart from the negative effect of corporal punishment, this research argues that in banishing corporal punishment, students became aware of their right to progress to the next grade and neglected the value of critical thinking. With every new education version it became harder to fail.

The challenge to develop competency in industry is becoming increasingly difficult. It is nearly impossible to develop high technology engineers when the pass mark in grade 12 is lowered from 50% to about 33%.

What is the rush in the system? The students are fast tracked into an advanced academic world at the age of 17 and 18. As discussed in the introduction, the degree does not guarantee a position in industry nor competency.

So is the system setting the youth up for failure?

What is failure? Is it:

- The inability to succeed the first time around?
- The fact that the student is not yet competent?
- The inability to progress at accelerated pace dictated by technology?

How do adults expect to develop optimism in the youth if such a person enters a new programme in his/her education continuum; they are set up for failure?

Students would be registering with any HEI that would have them, a phenomenon that emerged soon after the 1994 election when all schools were populated and there was an extreme mental shift in pursuit of national ownership. This is clearly the result of the State's strategy, successful or not.

Government policy enables all matriculants with appropriate grades to gain access to further their education at HEIs, whether ready or not. As a society, are we clear on the distinction between creative and dysfunctional?

Is failing a student that is "not yet competent" necessarily a bad thing? Could it be it becomes an opportunity to reassess competency and perhaps guide a student into an alternate career or stream?

For entrepreneurship in South Africa to flourish, entrepreneurs at HEIs must be confident and motivated. Reports have shown how dynamic entrepreneurship is. These reports showed that entrepreneurship often leads to rapid growing economies.

Pre-requisites for rapid growth are:

1. The development of a conducive entrepreneurship environment
2. Development of an entrepreneurial culture
3. Generating commitment and a desire to succeed

HEIs must:

1. Nurture entrepreneurship and not hinder progressiveness
2. Look beyond immediate problems and strategise to meet future demand
3. Develop optional streams to provide South Africa with a diverse workforce
4. Develop an entrepreneurial environment

2 Literature review

2.1 Institution challenge

The quality of the CPUT graduate constantly changes often leading to chaos. The changing relationship between the SEI, HEI and the industry described as "chaotic" is a mere state (Wheatley, 1992), until the institutions remodel their culture, "leapfrogging" into a new paradigm or state.

A "leapfrog" experience; a state – to – state change, is commonly known as innovation. Dr Rosabeth Moss Kanter (1983) in her work, *Change Management* says entrepreneurs are capitalist with an innovative flair. Innovation requires more than a fresh viewpoint, adequate market research, product design, secured finance and building a robust entrepreneurship environment.

Engineering entrepreneurship does not only support innovation in industry, but it creates new industries as a result of radical innovation (McDermott; O'Connor; Leifer, 2000). Logical incrementalism, introduced into this research by Quinn (1980, 1985), provides a progressive stance as opposed to the radical innovation stance of McDermott, however acknowledging the need for a strong-arm approach to challenge the existing paradigm culture thus effecting change. Quinn's (1985) introduction of logical incrementalism is an alternative way of thinking when dealing with uncertainties.

Before continuing to investigate incrementalism, innovation must be understood. In its simplest form, innovation means to modernise, advance or improve on an idea or premises. A more usual use of innovation is change.
Logical incrementalism (Quinn, 1985), the ability to delay commitment as long as is required in order to explore alternatives, sits well with this research.

Quinn makes the point, although the outcome is unknowable early on, logical incrementalism is the only "rational" option for the management of chaos and entrepreneurship.

The Quinn view on logical incrementalism with respect to chaos and entrepreneurship bemuse spectators to the entrepreneurial process due to the consistency of effort and also the patterning of the mind (1985). In neglecting to understand the fundamentals of the process, the onlookers fail to appreciate the "big picture."

Radical innovation is said to transform existing markets, create new industries and changes the game (McDermott, 2000), an intention diverse from that of Quinn (1980, 1985), whose primary concern is to manage uncertainty. Similar to *argumentative analysis, radical innovation seeks to deconstruct ideas from* different people, then to reconstruct them into improved or new paradigms. This is the essence of engineering, improving the lives of ordinary people (Ward & Angus, 1996)

Paradigms are useful when working in a team, as they provide a commonly understood environment. Petroski (1994, 1996) has shown over the centuries lateral perception and linear thinking has blinded engineers, causing what he terms "paradigm entrapment." These limited the scope for innovation and creativity. The uncertainty caused from "paradigm entrapment" is the foundation of innovation to be negotiated before effective compelling change could begin; Kanter (1983) cautions instant success takes time.

Petroski's theme of paradigm entrapment is aimed specifically at enlightening engineering design. The same caveat of paradigm lock-in is amply applicable to entrepreneurship, where a broadening of present paradigm is contemplated by this research (Petroski, 1994, 1996).

McDermott et al (2000) stress that products are changed, product ranges altered and how new industries emerge from radical innovation. This parlance helps to shape the ideology of this research.

McDermott et al (2000) place technology within entrepreneurship in saying that claims entrepreneurship embraces a wider technology innovation. This understanding adds impetus, helping to explain the research question:

"*Does entrepreneurship influence the technology innovation or the human endeavour, in the development life cycle of the technological product?*"

In short, McDermott's concept of radical innovation is valid in academic institutions when looking to prepare engineers for the global business place.

Wheatley (1992) articulates a need to adopt a radical stance when looking to mobilise entrepreneurship. Radical primarily means, new or different. She proposes a new environment for example, a move to a radical MTech program, or the introduction of new Bachelor degree of technology (BTech) models to drive diversification.

Perhaps paradigm entrapment is partly why the appeals of those such as Bygrave (1989a), Scott and Shaver (1991) and Quinn (1980,1985) for a change in attitude to entrepreneurship research, have not yet produced substantial improvements in the paradigms generally used to examine this complex human phenomenon of entrepreneurship.

2.2 Entrepreneurship

Entrepreneurship is fundamentally believed to stretch the boundaries of reason *and linearity, a design that contradicts and challenges theories in a bid to define* paradigms. This research is inclined to support the theory on non-linearity that instills a sense of forward momentum in spite of a lack of clear direction.

Entrepreneurship, at this point, will be difficult to analyse because of the elusive nature of one of the components, "the entrepreneur." Bygrave and Hofer's (1991) statement regarding entrepreneurship are captured in the following statement, "any theory of entrepreneurship must be rooted in the social sciences," reflecting a bias challenging the engineering environment. The engineer must draw on the strengths of the entire curriculum design to effectively contribute to entrepreneurship.

Bygrave's strong engineering background qualifies him to deliberate on the engineering – entrepreneurship relationship. He draws our attention to the limitation faced by entrepreneurship research, highlighting an unpredictability of this phenomenon when analysed mathematically.
He, furthermore, views entrepreneurship as a fledging when compared with more matured sciences, such as engineering. He refers to entrepreneurship as a collection of phenomena, a holistic entity that cannot be analysed when broken down into discrete parts. (Bygrave, 1989a)

The Bygrave views are fundamental to this research as they illuminate awareness vital to the understanding of the notion "discrete engineering" and "holistic entrepreneurship."

Bygrave is of the impression that entrepreneurship must be defined holistically and rationally. This demonstrates a need to put linearity aside as well as any preconceived expectations of predictive outputs. Says Bygrave, to analyse the

process by reducing it to its components, is oversimplifying the holistic process. Against this background of uncertainty, researchers such as Bygrave (1989a) and Mitton (1989) views this phenomenon entrepreneurship, a "collection of phenomena" within an entrepreneurship environment.

2.3 Entrepreneurship Environment

De Bono (1992) and Wheatley (1992) suggest the mind takes a holistic view when trying to make sense of chaos. It is really only when the mind takes the unknown and tries to define it in terms of the known that the chaos is estranged. Otherwise, as a stand alone model, chaos can not be managed.

Kanter (1983) says engineers need to "leapfrog" their thinking and realised that by nature they are capitalist; thus engineers are to some degree inherently entrepreneurial.
While HEIs find it difficult to model an entrepreneurial programme since the very nature of the entrepreneur is elusive, researchers Bygrave and Hofer (1991), places the entrepreneur inside the entrepreneurial process. Generally, one needs to accept that for now, the entrepreneurial process needs defining (Bygrave and Hofer, 1991) because of the elusiveness of the entrepreneur. Quinn (1980, 1985) assures academics that the mind will pattern the entrepreneurial process.

Shaver and Scott (1991) says the very choice the entrepreneurial engineer makes is reflected in their behaviour.
This research endeavours to understand the dynamics of linearity vs. non-linearity and thus engages the question:

"Within the well structured engineering environment, is there room for the non-linear human science?"

Engineering is a linear design within the physical sciences by rearranging the materials and forces of nature (Petroski, 1994, 1996). Not until scientists acknowledged the co-existence of linear and non-linear paradigms within a design, did one understand Petroski's theme of "paradigm entrapment."

According to De Bono (1992), only just recently, have mathematics allowed non-linear equations to answer problems linear equations could otherwise not resolve. The restrictions placed on engineering design, by linearity, have been nullified by enlightenment and the development of new paradigms.

One such paradigm known as "Stochastic Resonance" has recently been defined as a scientific phenomenon, allowing technologists to utilise non-linearities in practical scientific systems (De Bono, 1992). This introduction allows for a more open-minded approach as proposed by Petroski (1994, 1996). De Bono's model suggests once the brain had been exposed it reorganises its thought processes to develop a clearer picture of the model.

This established pattern allows for quick reference and analysis of new thought-data making the brain exceptionally good at complex pattern-recognition. Thus this self-organising patterning system builds on familiarity.

Mischel (1968) underpins in principle with De Bono's self-organising patterning system theory, saying that from the psychological definition, a person's behaviour is defined by the relation between the person and its environment.
The engineering environment must expand to embrace both linear and non-linear, order disorder the engineer and the entrepreneur. This research is led to believe that a changed faculty will present a united front and results will be evident (behaviour) in how it relates to the outside world.

Behind every action is a motivation, a thinking moulded through circumstance and external environment (Mischel, 1968). This research would see the study of the actions hindered by the lack of understanding of the environment, since the actors behaviour is a function of both person and environment.

Mischel's view certainly leads this research to consider that in a conducive environment, an engineer could well be influenced within the entrepreneurial

environment, evenually demonstrating a strong entrepreneurial behavioural pattern.

While Shaver and Scott (1991) focus on the process, this research centres on the environment. For within an environment, sub-environments co-exist, epitomising "holism." What interests this research is harmonious synergy creating optimistic energy through an interaction between person and environment (Mischel, 1968).

This is essentially coherent to Bygrave's concept of singularity, the person being superior within his environment. However so, within the holism of entrepreneurship, behaviour is one of "the collections of phenomena," as argued by Shaver and Scott (1991).

It becomes clear that if one aims to introduce entrepreneurship (non-linearity) into an engineering (linear) environment, there must be a paradigm shift says Shaver and Scott (1991). There must be concerted effort to adopt the non-linear, not necessarily forgoing the linear, but certainly seeking to harmonise both.

Petroski (1994, 1996) says this endeavour will demonstrate the commitment of the engineers to "leapfrog" the paradigm entrapped in.

This research will reason the entrepreneur, being a product of his behaviour (Mischel, 1968), holds unequivable control in his own environment (Bygrave, 1989a) that coexist with other environments, operating within the environment known as entrepreneurship.

This research is confident that the collective thinking (mind) of the school could be expanded to introduce the entrepreneurship dimension. Provided sufficient capacity for effectively integration of linear and non-linear exist.

2.4 Engineering Entrepreneurship

Bygrave and Hofer (1991) say the entrepreneur aught to be the centre of entrepreneurship, not the engineer. This directly implies a stronger sense of entrepreneurship in the engineering fraternity.

While Shaver and Scott (1991) articulate the appropriate motivation will help shape the behaviour of the person at the centre of entrepreneurship, namely the entrepreneur.

Quinn (1980, 1985) further helps the researcher to understand the relationship between the engineer and the entrepreneur, when he says that over time the mind absorbs new light and tries to make sense of it. The mind tries to normalise the state of chaos. De Bono (1992) adds to this trend of thought by saying the mind actually expands to accommodate new information and never loses the old information, merely repackages it.

Bohm and Peat (2000), say two worlds like engineering and entrepreneurship *can be unified. If so, engineers could be successfully sensitised to embrace* entrepreneurship.

Shaver and Scott (1991) supports the holism concept introduced by Bygrave and Hofer (1991), they support the inter-relation within a closed environment.

Bohm and Peat (2000) propose the bridging of two realms of sciences, especially between old and new paradigms. The '*flow from old to new paradigm*' is a design of inter-relationships that causes chaos, the co-existence of opposites (Wheatley, 1992). Bohm and Peat (2000) acknowledge the contribution made by others and argue that in chaos we need to find order. The idea of '*bridging the two realms of science*,' offers this research a cornerstone on which to build.

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Petroski (1994, 1996) was alert to paradigm entrapment and cautions one not to be caught in one state, but that we rather embrace the interaction between paradigms. Wheatley says only because we as actors embrace a certain ideology, that other philosophy is deemed unimportant and thus chaotic. This inability to deal with strange issues suggests some type of chaos. It is really only once we begin to define the '*strange*' that we adopt it as '*logical.*'

This type of thinking leads Wheatley (1992) to suggest that what appears to be chaos, really is '*different or undefined norm.*'

When the engineer makes sense of the business world, he begins to identify patterns (Quinn, 1980, 1985). As the uncertainty retreats, the fear of the unknown (Kanter, 1983) evolves into confidence that is disclosed in the engineer's behaviour (Mischel, 1968). Only when the mindset is changed to accommodate the integration of linear and non-linear, says Wheatley (1992), will the engineer appreciate the coexistence of order and disorder.

Engineers need to give themselves time to adopt the non-linear discipline and grow with it until such time uncertainty disappear and the hi-tech venture yield returns.

The co-existence of linear and non-linearity has illuminated the issue concerning the co-existence of engineering and entrepreneurship within a common fraternity. Furthermore, it offers this research an opportunity to investigate the co-existence of engineering qualities and entrepreneurship skills within the entrepreneur.

This research agrees with Bohm and Peat (2000) that the process of thought needs to flow freely between linearity and non-linearity in the closed environment. Mischel (1968) says that within a favourable environment energy will flow from engineering to entrepreneurship and vice versa. He seems to suggest an

engineer, typically a graduate, could probably begin to behave as an entrepreneur, if immersed in entrepreneurship.

This supports the De Bono's theory regarding the ability of the mind to expand to absorb new information. Here the engineer, typically a capitalist (Kanter, 1983), disclose traces of entrepreneurship, albeit underdeveloped.
Wheatley (1992) describes engineering management's reluctance to change as typical. Although the consensus is entrepreneurship is not an engineering discipline, it has a place within the engineering framework.

Bohm and Peat (2000) suggests an inter-relationship; this research agrees, since no one person is 100% engineer or 100% entrepreneur.

3 Research Methodology

3.1 Statement of Research Problem

New engineering employment opportunities are needed in the South African job market. Existing higher education channels do not cater for the addition of entrepreneurship to allow students this option.

3.1.1 Research Question

This research sets out to investigate whether the environment within the engineering faculty at CPUT is conducive to entrepreneurship by asking the following questions:

1. Is there a desire expressed by students for such an environment?
2. Does CPUT have the capacity to service such needs?
3. How would such a demand impact on the school output?

3.1.2 *Objectives of the Research*

The objective of this study is to measure the perception that engineering regarding entrepreneurship and wealth creation held by engineering students. In a changing employment environment, education plays a pivotal role in a desire to secure the best position in order to improve quality of life. HEIs have a propensity to impact on the quality of life of such graduates by providing diversified education that includes creating new hi-tech businesses.

3.2 Main Objective

The main objective of this study is to evaluate theory and investigate whether entrepreneurship can be encouraged to have a greater impact on the Department of Electrical Engineering at CPUT.

3.2.1 Secondary Objectives

In order to achieve the main objective of the study, one needs to look at secondary objectives:
Investigate literature to effectively articulate the need for HEIs to engage in *constructive entrepreneurship education.*
Investigate the perception of engineering students regarding their need for entrepreneurship training.

3.2.2 Methodology

The engineering school on both campuses of CPUT are taken as the area of study. The interview sample comprises entry-level and exit-level engineering students. The advantage at hand is that CPUT has a continuum that extends to BTech and beyond. CPUT is accessible to the researcher, a factor that will limit the cost of personal interviews.
The largely available literature provides a good research structure, hence the quantitative research methodology *also; the research question is relatively* predictive. The research question, having been widely researched, nullifies the exploratory research methodology that is the study of niche-area research. The *experimental and quasi-experimental methodology addresses research* questions concerning causality; that is not the focus of this research.

3.3 The Research Design

3.3.1 The Design of the Questionnaire

The questionnaires were designed according to the Likert-type five-point scale. The first section focus on the respondents' perception regarding ability. The last section on whether academia has contributed to the confidence of the respondents regarding their entrepreneurial ability to create wealth.

3.3.2 The Sampling Methodology

The empirical research is aimed at both the first year (133 students) and graduate (50) students in the Department of Electrical Engineering, CPUT. The sampling procedure will focus on the principle of randomness and the terms selected will constitute the elements of the target population. Quantitative data techniques will be employed for the final analysis.

3.3.3 The Data Collection

The need for consistency is tested, employing the quantitative method. Here students are subjected to a questionnaire probing for an understanding of entrepreneurship and the need for HEIs to provide an option for an alternate stream to enable graduates to begin and sustain a technical business.
Academics are subjected to semi-structured interviews, a qualitative research technique, to investigate two issues:

1. The HEI - industry relationship
2. Role of the school regarding entrepreneurship education

3.3.4 Delineation of the Research

The study of first year engineers in the engineering school at CPUT, the study of engineering graduates at CPUT, senior academics with service in excess of 10 years.

3.3.5 Significance of the Research

The significance of this study is to measure views held by engineering students regarding entrepreneurship and wealth creation. A confident and ambitious engineer has the potential to create wealth and contribute effectively to the SA economy by launching technology businesses.

3.3.6 Analytical Tool: SPSS

Statistical analysis was designed using SPSS software. The purpose of this exercise was to search for significant difference in views between first year students and BTech students. Scientific data was analysed to establish relevance. The key objective was to examine the different views between first year and BTech students.

The researcher also examined the difference in the views expressed by engineers and entrepreneurs regarding the research question.

The first set of tests measured the views of the sample regarding the sampling questions. The second set of tests measured the view of individuals who considered themselves engineers and persons who considered themselves entrepreneurs.

3.4 Purpose of research

Preliminary results already show entry-level and exit-level students agree a focused entrepreneurship programme would prepare them for greater leadership roles in industry. Both academics and students perceive entrepreneurship as the catalyst to unlock the unemployment problem in South Africa.

This research expects a consolidated view on the role that entrepreneurship education will present to the Department of Electrical Engineering and ultimately the industry.
This research seeks to find evidence in support of the GEM 2003 (Herrington et al, 2003) view regarding the potential benefits of entrepreneurship education.

The international industry has successfully unlocked its entrepreneurial wealth through focused education and the economy has reaped the benefit ever since. This research anticipates an alternative stream named "Entrepreneurial engineering" to be added to the suite of BTech streams. Furthermore, this research is of the view that the Department of Electrical Engineering will attract more postgraduates for the MTech course, thereby increasing the potential enrolment into the CIR producing an increased amount of sustainable high technology ventures as an alternative to joining existing industrial enterprises.

4 Summary of Results

1. BTech: 46% view themselves as being engineers; while 2% view themselves as being entrepreneurs. Significantly, 38% of the sample perceives themselves as both engineer and entrepreneur.
   First Year: 80% perceives themselves as an engineer; while 11% as an entrepreneur.

2. BTech: 96% of sample has strong engineering skills; 86% entrepreneurship skill.
   First Year: 92% of sample has strong engineering skills; 74% strong entrepreneurial skills.

3. BTech: 38% of the sample says the school offers a choice between engineering and entrepreneurship.
   First Year: 69% of the sample says the school offers a choice between engineering and entrepreneurship.

4. BTech: 88% of sample wants a business driven entrepreneurship stream. (The question was exclusive to the BTech sample.)

5. BTech: 96% of sample identified a need for industry interaction; 98% considered specialist education as important.
   First Year: 95% of sample identified the need for industry interaction; 92% considers specialist education as important.

6. BTech: 86% of sample wants to be employed; while 88% wants to be self-employed as an entrepreneur.
   First Year: 89% of sample wants to be employed; 80% wants to be a self-employed entrepreneur.

7. BTech: 34% of sample has above average entrepreneurial skill; 36% show average skills.
   First Year: 50% of sample has above average entrepreneurial skill; 28% has average skills.

8. BTech: 6% of sample felt HEIs contributed to their entrepreneurial skills; 42% felt the contribution was average.
   First Year: 32% of sample was happy the SEI had contributed to their entrepreneurial skills; A further 25% felt the contribution was average.

9. 96% of the BTech sample, together with 81% of the first year sample wants a strong entrepreneurship training programme at CPUT engineering school, to prepare them to face the business responsibility in the real world as either an engineer or an entrepreneur.

4.1 Empirical Data Analysis

The sample comprising 50 BTech and 133 first year students, represents the entire electrical engineering population at CPUT. The response from the sample represents the academic and student perceptions.

4.1.1 Engineer vs. Entrepreneur

Figure 4 below shows the BTech sample has a strong engineering (96%) confidence as well as a keen entrepreneurship (84%) interest.

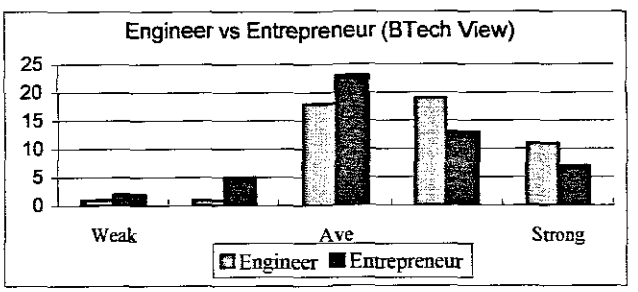

Figure 4: Engineer vs. entrepreneur (BTech)

Figure 5 below shows the first year student has a strong engineering (92%) confidence as well as a keen entrepreneurship (74%) interest.

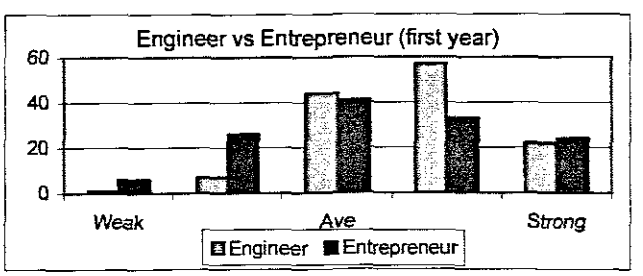

Figure 5: Engineer vs. entrepreneur (1st Year)

4.1.2 The Graduate

Technology graduates thought they were ready to make a significant contribution to society and also generate wealth. This basic desire is clearly derailed by an inability to raise skills to produce a product and develop a marketing plan.

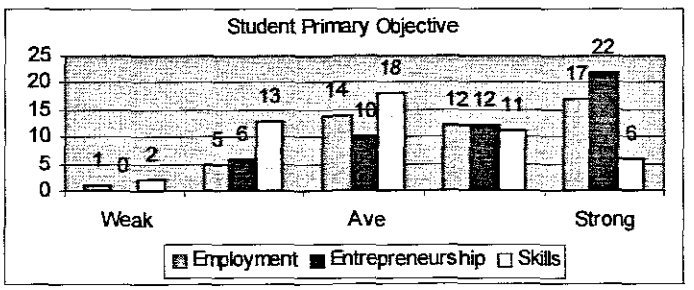

Figure 6: Students' objectives (BTech)

Figure 6 above shows BTech graduates feels strongly about income generation, albeit employment or entrepreneurship.

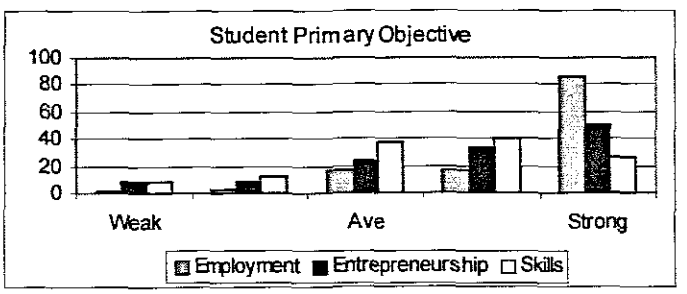

Figure 7: Student's objectives (1st year)

Figure 7 above shows the first year feel strongly about a job. At this stage one cannot really expect them to be aware of the dwindling job market, hence the youthful optimism.

4.1.3 HEI vs. SEI

Generally the respondents thought they had poor entrepreneurship skills. BTech students persistently looked beyond their 'entrepreneurial specialist inability', focusing more on the potential benefits of being 'entrepreneurial skilled.'

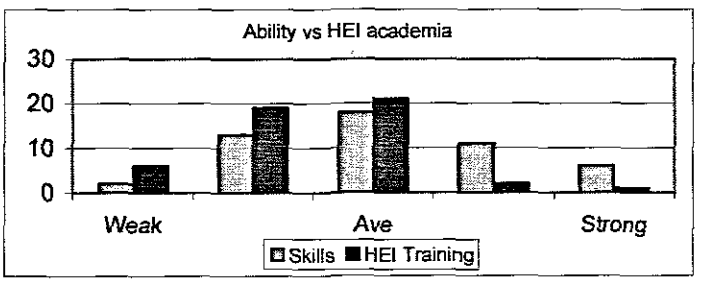

Figure 8: HEIs' impact on student

Figure 8 above shows that 1st year students ignorantly showed they have the skills to go into business for themselves. The question at hand is thus, "where were the skills of the 1st year students developed?, clearly not at CPUT"

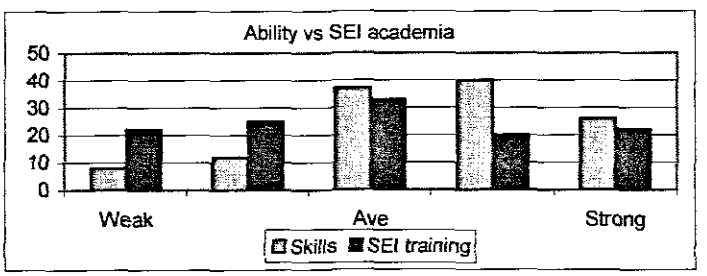

Figure 9: SEIs' impact on student

Figure 9 above shows 92% of 1st year students believe the SEIs did little to foster entrepreneur Also, 92% of 1st year students believe they have ability to master entrepreneurship.

4.1.4 Environment

This research asked the question, "What would help to improve the environment, making it more conducive to entrepreneurship?" The data shows 60% of respondents felt they had no clear option to choose when looking at the future impact of entrepreneurship on careers.

The research investigated ways to improve the environment at the engineering school. Figure 10 shows that in 2004, "specialist education" and "business interaction" were considered the catalyst.

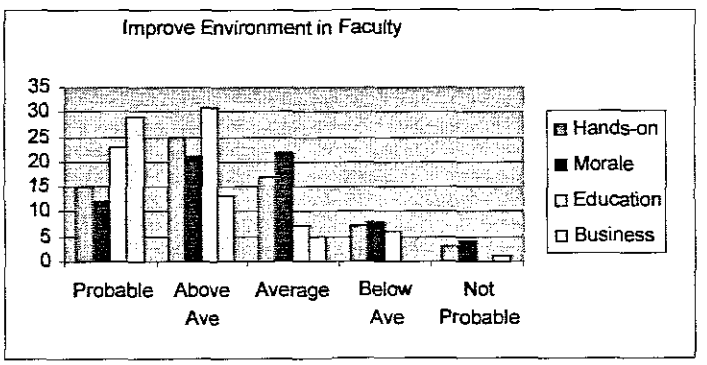

Figure 10: Improving the entrepreneurial environment

Building on the theme of 2004 the survey showed the 2005 sample
Figure 11) also considered "specialist education" and "business interaction" as critical to altering the entrepreneurship landscape at the school. Of 50 interviews, 96% saw the potential presented by entrepreneurship in the school.

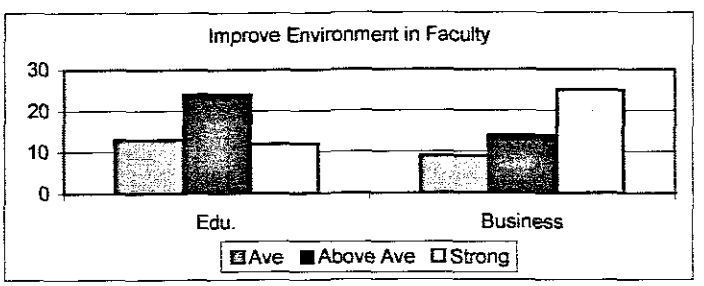

Figure 11: Education and Business improve the entrepreneurial environment

4.1.5 Entrepreneurship

Figure 12 clearly shows that the request for entrepreneurship training was remarkable. This is consistent with BTech findings in identifying "specialist education" as being critical to improving the environment.

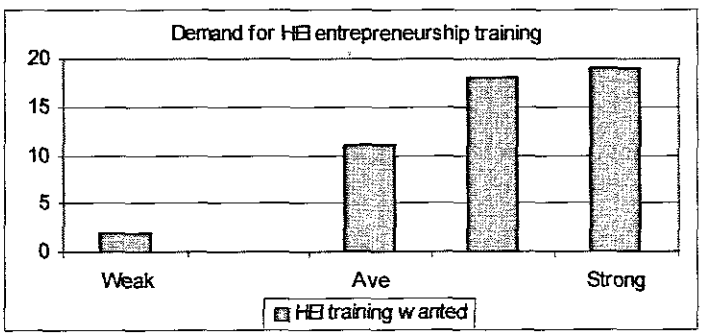

Figure 12: Need for entrepreneurship training at HEIs

Figure 13 suggests the demand for entrepreneurship training was awe-inspiring. This is exciting since these first year students would not be up to date about the joblessness in industry, the mechanics of entrepreneurship. Be this as it may, the data is consistent with the BTech findings in identifying "specialist education" as vital to improving the environment.

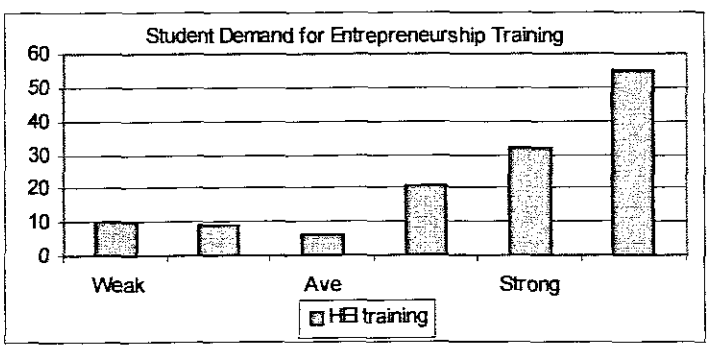

Figure 13: Student identify a need for entrepreneurship

4.1.6 Alternate Stream

On testing whether respondents wanted an alternate engineering stream, the response (88%) overwhelming "Yes."

Table 1: Request for alternate engineering stream

Question	**Want Alternate?**	
Response	Y	N
Stats	44	6

With a dwindling job market, students are left exposed to their own demise. Having embraced a need to control their futures, they identified "specialist entrepreneurship skills" as being critical to that future. Figure 14 articulates the views of engineers regarding an alternative to a dwindling job market.

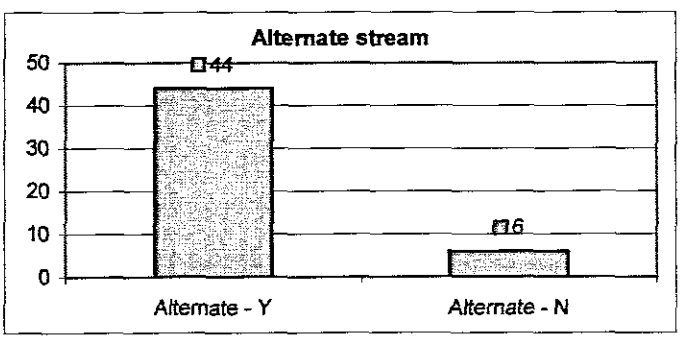

Figure 14: Student demand for entrepreneurship

Figure 14 suggests BTech students, in the process of completing degrees are cognisant that finding a job in industry might not be the natural progression to follow higher education. In realising the value of an alternate stream, these final year students are saying that although PK is the "currency" of industry, it does not guarantee them a job. At this juncture graduates seem to realise entrepreneurship could be an admirable alternative to a job in industry.

4.2 Findings

These are the results of a survey measuring perceptions at CPUT among 133 first year and 50 BTech engineering students.

4.2.1 People Skills

First year: Very weak engineers had excellent people skills. Average engineers had average people skills; Very strong engineers had strong people skills. This engineering skill was directly proportionate to the people skills.
The BTech: both the very weak entrepreneur and the very strong entrepreneur rated people skills excellent.

4.2.2 Entrepreneurship Skills

All entrepreneurs were unconvinced they had acquired skills needed for entrepreneurship.
The weaker engineers felt they were skilled, while stronger engineers felt less resolute about their skills.
The BTech engineers felt they had average skills.
All the engineers felt very strongly about entrepreneurship.

4.2.3 Preparedness

First year: Entrepreneurs were not convinced they were prepared by the HEI to venture into entrepreneurship.
BTech: Entrepreneurs felt less resolute than first year students. The engineers were convinced they were not prepared to venture into entrepreneurship.

4.2.4 The Collective View

The students were probed to find whether entrepreneurship education would give them an edge to get to grips with entrepreneurship the general feeling from entrepreneurs and engineers alike as entrepreneurship was the way of the future, the stimulus for wealth creation.

4.3 Findings discussion

4.3.1 Practical Knowledge (PK)

The level of competency regarding people skills is directly proportionate to the perception regarding engineering. However, the perception among entrepreneurs is that strong entrepreneurs are people centric, and the data confirms this. If the very weak entrepreneur is compared to a strong engineer on a linear scale then it makes sense that the weaker entrepreneur also has strong people skills.

Continuing with the points that in many instances engineers are inversely proportionate to entrepreneurs, engineers have excellent leadership skills; *entrepreneurs were less resolute.*

In an engineering environment students are alert to the fact PK involves conceptualisation and contextualization, two skills that develop over time. Both Autio (2003) as well as the 2003 GEM report states that the age of the entrepreneur was on the decline and certainly the data affirms that.

The only aspect of PK is the industry experience: could a student gain valuable *experience outside industry?*

4.3.2 Theoretical Knowledge (TK)

A sustainable business conforms to a culture and certainly the white male in a stable job subscribes to such a culture. Government has been working hard to provide entrepreneurship framework and develop a culture of small business practice. This paper looks at the education, persistence and the determination of students who are in the process of redefining the South African landscape.

Engineers and entrepreneurs alike do not feel positive about their preparedness. Their skills also proved to be an area of concern where perception is portioned to the perception regarding their status as engineers.
Students across the board recognise entrepreneurship as being vital in their education portfolio, irrespective of whether they choose to be an entrepreneur or an engineer.

4.3.3 Character Traits according to GEM

The sample shows excellent determination and relatively good persistency traits. Table 2 depicts that initiative and leadership are significant character traits looking to make a distinction between entrepreneurship and engineering. While entrepreneurs have good leadership skills they generally lack excellent management skills, a quality synonymous to engineering. However, the entrepreneur reveals excellent initiative and creativity, a trait that often prohibits radical thinking and innovation amongst engineers.

Table 2: Engineering character traits (Herrington et al, 2003)

Engineers showed:	***Entrepreneurs showed:***
Good initiative	Excellent initiative
Relatively good persistence	Relatively good persistence
Excellent determination	Excellent determination
Excellent leadership	Good leadership

5 Conclusion

The engineering school at all universities has a primary responsibility to produce world-class engineers. Yet for South Africans to take ownership of their future they must be empowered to make choices to that effect. In order to become wealth creators, graduates must be educated to understand the dynamics regarding the economy.

A changing global economy has forced change on the South African economy. This has also caused industry to change. With higher education technology graduates need to develop skills to equip them for this global market. Graduates therefore, need entrepreneurial skills as well to meet and reverse the negative growth in the skills market.

Mixing engineering and business is sometimes like mixing water and oil (Campbell, 2001) especially in the education context. Importantly, entrepreneurship is the catalyst for the potential mix between engineering and SMME, but it requires a culture of thought a new way of doing things.

CPUT must grow a culture of entrepreneurial enlightenment inline with national vision. It is no longer sufficient to talk about entrepreneurship; there must be accelerated entrepreneurship development at all level of education in order to compete against other emerging countries.

The entrepreneurial culture will:

1. Enable engineers to develop people skills
2. Enable engineers to develop both technical and non-technical skills
3. Provide all South Africans with an opportunity to create wealth
4. Provide South Africa with diverse engineering skills

We need a programme to change the mindset of academia, and to help improve the technologist / entrepreneur ratio at CPUT. Certainly when government, academics and South African business pools their resources a culture of entrepreneurship and technological excellence awaits. The success of this process, critical to job creation, could be realised only in an environment favourable to entrepreneurship.

5.1 Future

Science continuously needs to look into the past to understand the immediate position and to develop a strategy to manage the future. HEIs, such as government, kingdoms, regimes, and the like, have gone through various "revolution." In the South African context, rapid change is indicative of a revolution. HEIs are at the heart of such a revolution, at the heart of change.

The global market is changing, the local market is changing, industry is changing, the student is changing, and hence HEIs must change.
South Africa, as an emerging economy, is in constant change. This needs to be supported by a changing industry that must be underpinned by a changing HEI.

The timelines suggested by the 2003 GEM report leads this researcher to believe that the TK, gained at HEIs need to be fundamental and prescriptive of the PK gained in industry. Engineering practitioners must be adequately educated and experienced to implement life-changing choices.

Entrepreneurship is people-centric (Gillin, 2005). The empirical data confirmed students perceive the future to be challenging. They confirm HEIs have not contributed significantly to understanding their futures as wealth creators. Students recognised their lack of skills and competency, yet are clearly enthusiastic and optimistic about the future with the introduction of entrepreneurship education.

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Appendix A

Appendix A

Questionnaire for B-Tech students at Cape Peninsula University of Technology

1. Will you complete your Electrical Engineering B-Tech degree this semester? **Y / N**

2. How would you describe yourself regarding each of these categories? **(On a scale from 1 to 5, 1 being weak & 5 being very strong)**

		1	2	3	4	5
A	You like Product Designing					
B	You have strong planning & controlling skills					
C	You manage people well					
D	You liaise with customers & suppliers well					
E	You are more confident within a group					
F	You often use your own initiative					
G	You are a Persistent person					
H	You are a Determined person					
I	You have strong Leadership skills					
J	You have strong Engineering skills					
K	You have strong Entrepreneurship skills					

3. What, for you, defines an engineer? **(Circle the best fitting option)**

   A *Technical Education*
   B Producing a working project
   C Graduating as an Engineer
   D Being accomplished in designing, developing, testing and maintenance.

4. What, for you, defines an entrepreneur? **(Circle the best fitting option)**

   A Taking risks
   B Planning your engineering company
   C Managing a team of specialists
   D Leading a team through the life cycle of a product
   E Constantly evaluating options and testing new product ideas

Please the circle the relevant answer

5. Are you an engineer, entrepreneur, both or other?

6. Does the school offer a sufficient range of courses that could allow you to decide between a career as an engineer or as an entrepreneur? Y / N

7. Should the electrical engineering school, offer engineering entrepreneurship, as an alternate stream for students who wishes to work for them? Y / N

8. On a **scale from 1 to 5**, in your opinion, what could help to improve an environment, making it more conducive to entrepreneurship? **(1= weakest & 5 = strongest)**

		1	2	3	4	5
A	Specialist hands-on tutoring?					
B	Improved Morale					
C	Specialist Education					
D	Interaction with business					

9. In your understanding of industry; how important, **on a scale from 1 – 5**, are these aspects in your project? **(1 being weakest & 5 being strongest)**

		1	2	3	4	5
A	Industrialisation (design the outside casing of the product)					
B	Market research (identify the people interested in product)					
C	Customer expectation (identify what the customer expects)					
D	Aesthetics (knowing the right colour, shape, finish)					
E	Documentation (all aspects of the product is documented)					

10. In your understanding of Small, Micro & Medium Enterprises; how relevant, **on scale from 1 – 5**; are these issues? **(1 being lowest & 5 being the highest)**

		1	2	3	4	5
A	Commercialisation (product ready for sale)					
B	Funding for prototype (financing for development)					
C	Designing (time needed for prototype)					
D	Presentation (present prototype to stakeholders)					
E	Customer service (support customer queries)					

11. What are you likely to be doing; **on a scale from 1 – 5?**
(1 being lowest & 5 being the highest)

		1	2	3	4	5
A	Do you want to be employed?					
B	Have you considered working for yourself as an Entrepreneur?					
C	Do you have the skills to be an entrepreneur? (Costing, IT, Ops, design, people skills, marketing, planning, economics)					
D	Has your CPUT training developed your entrepreneurial ability and skills?					
E	Do you want a strong entrepreneurship-training program at CPUT to prepare you for your own business?					

Thank you for your time and energy.

This research will be used to:
1. Establish whether an environment for entrepreneurship exist
2. Establish whether students perceive entrepreneurship as important.

Appendix B

Appendix B

Questionnaire for students at
Cape Peninsula University of Technology

1. Which school are you from? ----------

2. How would you describe yourself regarding each of these categories?
(On a scale from 1 to 5, 1 being weak & 5 being very strong)

		1	2	3	4	5
A	You prefer doing Research & Development					
B	You have strong planning & controlling skills					
C	You can manage a project					
D	You manage people well					
E	You are very creative					
F	You are more confident within a team					
G	You use your own initiative					
H	You are a Persistent person					
I	You are a Determined person					
J	You have strong Leadership skills					
K	You have Engineering skills					
L	You have Entrepreneurship skills					

5. What, for you, defines an engineer? **(Circle your choice)**
   - A Technical Education
   - B Producing a working project
   - C Graduating as an Engineer
   - D Associating with engineering specialists

6. What, for you, defines an entrepreneur? **(Circle your choice)**
   - A Taking risks
   - B Planning your engineering company
   - C Managing a team of specialists
   - D Constantly evaluating options and testing new product ideas

7. Are you an engineer, entrepreneur or other? **(Circle your choice)**

8. Does the Engineering faculty offer a range of courses that allow you to choose between engineering and entrepreneurship? **Y / N**

9. On a **scale from 1 to 5**, in your opinion, what could help to improve engineering entrepreneurship? ***(1 being weakest & 5 being strongest)***

		1	2	3	4	5
A	Specialist hands-on tutoring?					
B	Improved Morale					
C	Specialist entrepreneurship education					
D	Interaction with business					

10. What are you likely to be doing; **on a scale from 1 – 5**?
(1 being lowest & 5 being the highest)

		1	2	3	4	5
A	Do you hope to find a job?					
B	Do you want to be employed?					
C	Do you want to be a manager?					
D	Do you want to work for yourself as an Entrepreneur?					
E	Do you have the attitude to be an entrepreneur? (Persevere, planning, people skills, marketing, outspoken)					
F	Has your school training developed your entrepreneurial ability?					
G	Do you want a strong entrepreneurship-training program at CPUT to prepare you for your own business?					

Thank you for your time and energy.

This research will be used to:
1. Establish whether an environment for entrepreneurship exist
2. Establish whether students perceive entrepreneurship as important.