Towards an Innovation and Entrepreneurship Ecosystem: A Case Study of the Central University of Technology, Free State

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According to the Global Entrepreneurship Monitor (GEM) 2015 Global Report (GEM, 2015), South Africa (SA) had the lowest youth entrepreneurial propensity of only 23.3 per cent. Among the sub-Saharan African countries surveyed, Uganda recorded the highest youth entrepreneurs with 55.6 per cent of the youth population involved in nascent, new or established businesses. South Africa had the lowest youth entrepreneurship participation of only 12.8 per cent, and recorded the highest level of non-entrepreneurial youth with 63.9 per cent of the youth population (GEM, 2015). According to Puuka (2014), SA has not yet unleashed its entrepreneurial potential. Despite the importance of small- and medium-sized enterprises for the economy and job creation, SA's established business rate is only 2.3 per cent—the second lowest in the world. South Africa needs new job creators to solve the job crisis. A new philosophy and approach to education in general are required; more specifically in a higher education sub-system of universities of technology in SA that is designed to lead to work opportunity-enhancing outcomes. The Central University of Technology, Free State (CUT), SA has, in line, with its Vision 2020 that focuses on producing quality social and technological innovations for socio-economic developments set a goal of transforming CUT into an innovative and entrepreneurial university, and of becoming a robust agent for socio-economic development in the city and the region. This article gives an overview of the Innovation and Entrepreneurship Ecosystem established at the University, the city and the region; the creation of an increasingly robust innovation and entrepreneurship pipeline; and initiatives that started in 2012 in the field of curriculum innovation, and innovation and entrepreneurship education later in 2014. These initiatives, together with international examples cited, show that universities could pursue the path to innovation and entrepreneurship education with

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outcomes that impact the broader society. True to the universities of technology's general philosophy of education, the path involves innovation, entrepreneurship education, research, idea generation and technology transfer. Based on a literature study of global perspectives on entrepreneurship education and lessons to be learnt, the paper discusses the enablers to promote entrepreneurship education at CUT and key elements of the University's Innovation and Entrepreneurship Strategy. Furthermore, it shares successes and some challenges of these efforts at CUT, which are evident in the increasing national recognition of our innovation and entrepreneurship activities. The impact of the Innovation and Entrepreneurship ecosystem on the knowledge production from CUT in the past few years are also illustrated. The article concludes that the overarching challenge to ensuring high impact and relevance is dependent on the development and successful implementation of an Innovation and Entrepreneurship Ecosystem, buy-in of all internal and external stakeholders and dedicated resources.

Introduction

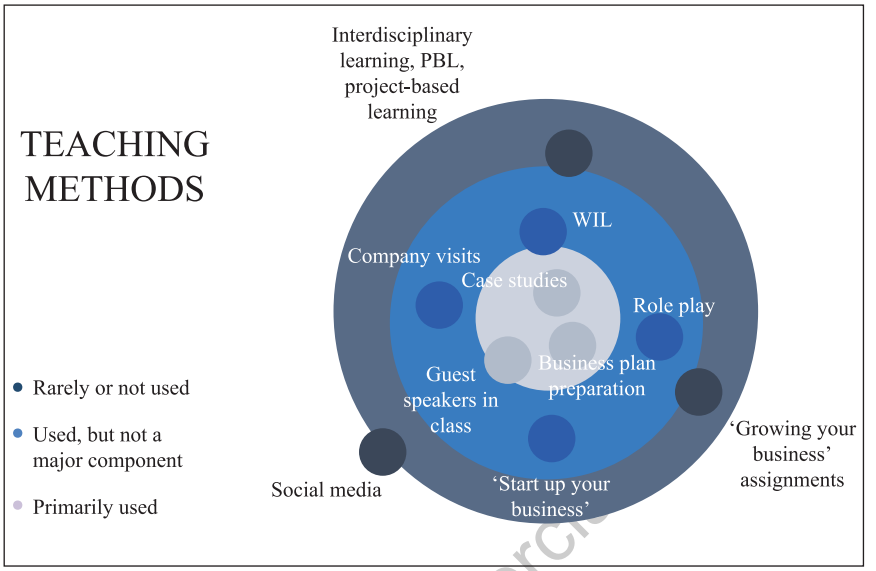
According to the Global Entrepreneurship Monitor (GEM) 2015 Global Report (GEM, 2015), some African economies showed the highest social values towards entrepreneurship. Among the sub-Saharan countries surveyed, Uganda recorded the highest youth entrepreneurial propensity with 55.4 per cent, followed by Malawi (52.3 per cent) and Namibia (44.1 per cent). South Africa (SA) had the lowest percentage at only 23.3 per cent. Concomitantly, Uganda recorded the highest number of youth entrepreneurs with 55.6 per cent of the youth population involved in nascent, new or established businesses, while SA had the lowest number at only 12.8 per cent. At least 60 per cent of the youth population in all countries except SA showed entrepreneurial propensity or were currently actively pursuing an entrepreneurial opportunity. South Africa recorded the highest level of non-entrepreneurial youth, with 63.9 per cent of the youth population who were non-entrepreneurs, while 10 per cent or less of youth population in Zambia and Uganda were non-entrepreneurs (GEM, 2015).

According to Puuka (2014), SA has not yet unleashed its entrepreneurial potential. Despite the importance of small- and medium-sized enterprises for the economy and job creation, SA's established business rate is only 2.3 per cent—the second lowest in the world. South Africa needs new job creators to solve the job crisis. A new philosophy and approach to education in general are required; more specifically in a higher education sub-system of universities of technology in SA that is designed to lead to work opportunity-enhancing outcomes.

Vision 2020 of the Central University of Technology, Free State (CUT) states that '*By 2020, CUT shall be an engaged university that focuses on producing quality social and technological innovations for socio-economic development, primarily in the Central region of South Africa.*' CUT must be an *isle of innovation*, where 'isle' is the acronym for **i**nnovation, **i**mpact and outcomes; **s**ocio-economic development; **l**ocation and **e**xcellence. In order to realise Vision 2020, it is important for the University to enhance its innovation and entrepreneurship ecosystem. Puuka (2014) conducted an extensive study on CUT's teaching methods relevant to entrepreneurship, and concluded as indicated in Figure 1.

According to Kachieng'a (2014), CUT—and we could add other universities of technology (UoTs), too—is '*sitting on a technological gold mine'*. Therefore,

Figure 1
CUT Teaching Methods Relevant to Entrepreneurship in 2014



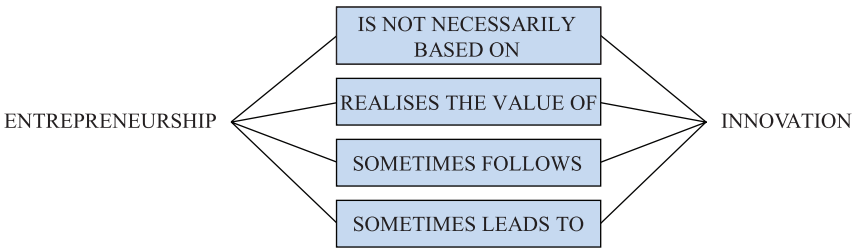
Source: Puuka (2014).

CUT and other UoTs should establish strong 'value-capturing' linkages and collaboration with business and industrial establishments through enhanced technological education modules and programmes, in order to convert its technological assets into a productive educational advantage. Kgaphola and Mthembu (2014) mention that, in a modern economy, education must be used as a basis for creating something new, either by way of artefacts, services, products, ideas, processes or applications, as these are elements that constitute innovation. Universities in particular must redirect their educational offerings towards cultivating a culture and ethos of innovation and entrepreneurship across all modules and programmes. While we acknowledge these goals, we are aware that any successful movement starts from the smallest of initiatives. Thus, success is unlikely to be achieved via a 'big bang' approach, but through smaller incremental steps that may not permeate the whole curriculum, but selected programmes within it.

Bement, Dutta and Patil (2015) argue that 'innovation is an improved product, process or service that benefits society in a timely and, sometimes, transformational manner. It is a team activity at the intersection of different fields, bringing together diverse ideas, abilities and/or methods to result in the creation of value.' Innovation creates societal value (through an existing or new product, process or service) and entrepreneurship involves realising the market value of an opportunity, not necessarily an innovation, but making it commercially or socially viable.

Although both innovation and entrepreneurship are focused on 'value' they differ fundamentally in that innovation focuses on its creation while entrepreneurship focuses on its commercial or social realisation. Not all innovations lead to

Figure 2
Different Ways of Relating and Differentiating Innovation and Entrepreneurship



Source: Bement et al. (2015).

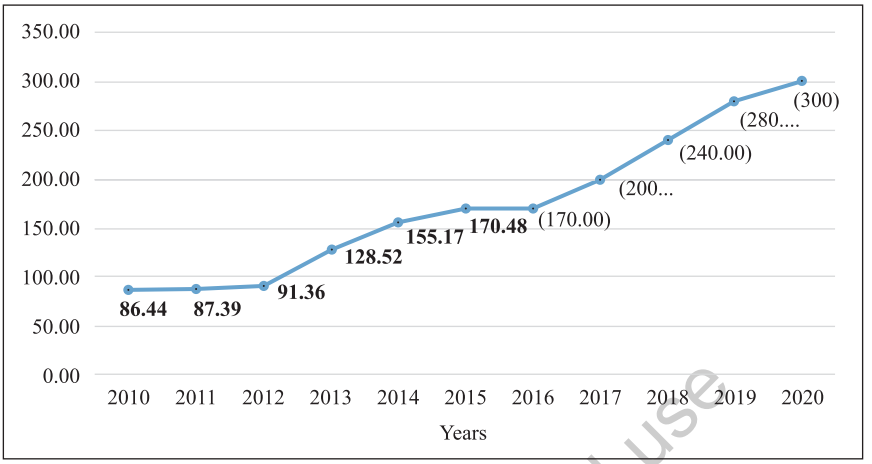
an entrepreneurial venture and not all entrepreneurships are based on one or more innovations, as illustrated in Figure 2. Hence, while entrepreneurship education should clearly promote the continuum between innovation and entrepreneurship, it must be made clear that it is not limited to this continuum as there are other aspects of entrepreneurship that are not directly related to innovation.

Puuka (2014) argues that the success of CUT in developing competitiveness, innovation and economic growth in the Free State and the Central region depends to a great extent on its ability to produce graduates with the skills and attitudes to be entrepreneurial in their professional lives, whether by establishing their own companies or innovating in larger organisations in the public, private or the voluntary sector.

Generally, there is increasing interest in most-developed and developing nations and their governments of finding better ways of tapping into universities to stimulate the processes underpinning growth. Science parks have been found to have a role to play here. A science park is an organisation managed by specialised professionals, whose main aim is to increase the wealth of its community by promoting the culture of innovation and the competitiveness of its associated businesses and knowledge-based institutions. To enable these goals to be met, a science park stimulates and manages the flow of knowledge and technology amongst universities, R&D institutions, companies and markets; it facilitates the creation and growth of innovation-based companies through incubation and spin-off processes and provides other value-added services together with high quality space and facilities (IASP, 2002).

A science park has two main objectives. The first is to act as a catalyst for regional economic development, while the second relates to facilitating the creation and development of new technology-based companies and knowledge transfer from universities to companies, thus catalytic agents. They form a medium facilitating innovation and the dissemination of knowledge. Examples of two universities that have made effective use of incubators based on science parks are: Twente—Spin Out Company Formation, the TOP Programme; and Warwick University Enterprise Fellowship Scheme (EFS). The Warwick Enterprise Fellowship Scheme (EFS) is based on the University of Twente TOP model and was introduced to the University of Warwick by its science park who had made a study of 'Unispin' programmes across Europe a few years before. The science park then bid for and secured a substantial European Union grant to run a 2-year pilot for EFS. The Park handed

Figure 3
Weighted Research Outputs of CUT from 2010 to 2015



Source: De Jager. HJ. (2017).

over operation of the project to the University but provided interest-free loans from its own resources to the University Enterprise Fellows and was involved in the selection of candidates for the programme. Some of these aspects are addressed in the section '*Knowledge Production at CUT* and the CUT Innovation and Entrepreneurship Ecosystem illustrated in Figure 3.

It can be argued that the University of Twente and the University of Warwick are indeed entrepreneurial universities. On the question of whether CUT is an entrepreneurial university, Dahms (2014) responds that the University agreed to instil graduate attributes in its students, improve the 'whole' graduate, contribute to the economic growth and meet the demands of the external environment, and Vision 2020 is clearly guiding CUT to become an entrepreneurial university. The recently approved Strategy on Innovation and Entrepreneurship, with specific reference to incubation, technology transfer and intellectual property, adds more impetus towards becoming an entrepreneurial university, with the relevant outcomes in the socio-economic development arena, first and foremost, in the region.

A Global Perspective on Entrepreneurship Education: Lessons to be Learnt from the Literature

Taalita (2010) describes entrepreneurs according to their ability to adapt to the changing demands of their customers and own business environment, as well as their ability to offer a constant process of innovation to societies, no matter whether such innovation is a service or a physical product. Entrepreneurship is the ability of a person to turn ideas into actions (European Commission, 2012). It entails being creative, taking risks, planning and managing. The development of the right mindset, knowledge and skills as foundations for entrepreneurship requires

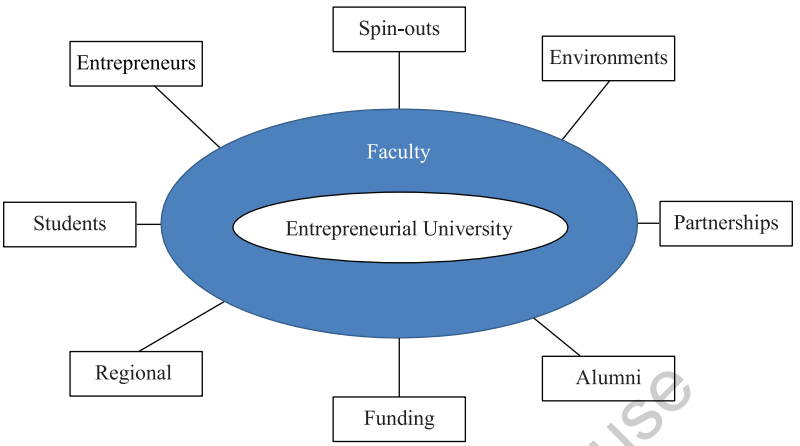
appropriate entrepreneurship education within higher education institutions, focusing on students by building their attitudes, knowledge and skills for the purposes of entrepreneurship. Both skills and knowledge help students recognise and capitalise on entrepreneurial opportunities (Nichter & Goldmark, 2009).

In all countries of the world, education has been recognised as the engine for economic growth and as a catalyst for national transformation. All discussions on poverty reduction, wealth creation and innovation begin with education. In today's knowledge-based economy, individuals of any country need the right type of education and training to be able to function effectively in their society, create wealth and compete globally. The skills base of a nation's human capital can be developed at institutions of higher learning via entrepreneurship education and training (Asiyai, 2013). Therefore, becoming an entrepreneur requires efficient and effective education and training, which in turn requires a driving spirit characterised by creativity, critical thinking, initiative, innovation and risk taking. We can no longer assume that the education we provide will willy-nilly and by default lead to entrepreneurial outcomes. Our philosophy, curriculum design and delivery must be purposeful and fit for purpose.

Entrepreneurship at higher education institutions is not only necessary, but also essential. However, the ultimate goal would be to transition an institution from offering entrepreneurship education to being an entrepreneurial university, of which the outcomes of its education must reverberate in societal development. It is no longer enough to educate even entrepreneurially and hope that the outputs and outcomes will be self-evident. An entrepreneurial university '*actively seeks to innovate in how it goes about its business'* (Peppler, 2013). It seeks to work out a substantial shift in organisational character, so as to arrive at a more promising posture for the future. Examples of such universities include Twente University in the Netherlands, Warwick University in England, Chalmers University in Sweden, and many others. There is an evolutionary process within the university community that moves a university towards becoming an entrepreneurial university (Peppler, 2013). The pivotal role of entrepreneurship education in universities should be put on the 'front-and-centre' stage in universities. Hautanen (2015) argues that the entrepreneurial university's heart should be the centre of dynamic entrepreneurship, as indicated in Figure 4.

According to Nicolaides (2011), higher education institutions (HEIs) have an important role to play in regional innovation systems, and should strive to carefully consider local development needs and support the promotion of entrepreneurial education initiatives to meet the socio-economic needs of the country. Clearly, the focus on local and regional needs is paramount, as development in a country does not emerge evenly and simultaneously from all the sectors of the economy. The primary function of HEIs, especially UoTs, should thus seek to instil a greater entrepreneurial character among students. Students must be taught to identify opportunities in the marketplace and their potential risks and should also be assisted to innovate and create something different when establishing a new venture.

Figure 4
The Entrepreneurial University



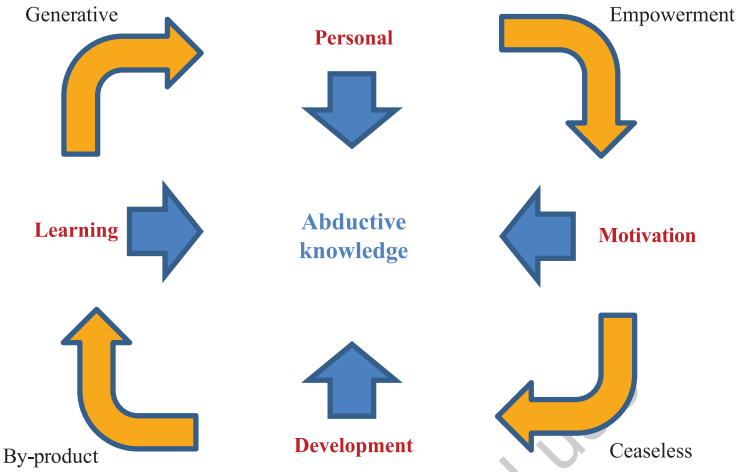
Source: Adopted from Hautanen (2015, p. 1).

The outcome of dynamic and high-growth businesses (with job creation potential) requires universities to be vibrant entrepreneurship ecosystems characterised by the breadth and depth of initiatives/offerings across three major dimensions: academic entrepreneurship, enterprise and support, and entrepreneurial behaviour (Peppler, 2013). The ultimate aim is to shift higher education institutions from merely offering academic entrepreneurship with less regard to sustainable outcomes in the local socio-economic arena, to becoming entrepreneurial universities (Peppler, 2013).

Asiyai (2013) argues that the major challenges facing the effective implementation of entrepreneurship education in higher education are funding, lack of entrepreneurial curricula, acute shortage of facilities and equipment, lack of infrastructure and lack of skilled staff. The challenge posed to universities and individuals tasked with developing and delivering entrepreneurship education is building sustainable communities of learning that balance the requirements of academic rigour with the realities of entrepreneurship (Winkel, Vanevenhoven, Drago, & Clements, 2013). The personal experience a student gains in such an environment is of crucial importance in creating the required holistic competence set of psychological and business substance skills required of an entrepreneur (Taalita, 2010). The HEIs should provide their students with more learning opportunities for and in an enterprise, in order to increase the effect of entrepreneurial education, as is indicated in the Entrepreneurial Learning Cycle, shown in Figure 5.

Many universities have accepted entrepreneurship as an integral and nuanced part of the 'third mission' of engagement, along with their traditional teaching and learning, and research and innovation goals, in order for entrepreneurship education to be considered as an established part of higher education. With this comes a huge potential not only for entrepreneurship education, but for society as a whole.

Figure 5
The Entrepreneurial Learning Cycle



Source: Adopted from Taalita (2010).

On many occasions, students exhibit an enormous interest in entrepreneurship and have huge creative potential and many ideas of what could or should be done, but they unfortunately lack the knowledge and skills to transform that potential into creating new businesses. It is our responsibility as entrepreneurship educators to help them realise that potential (Kuckertz, 2013).

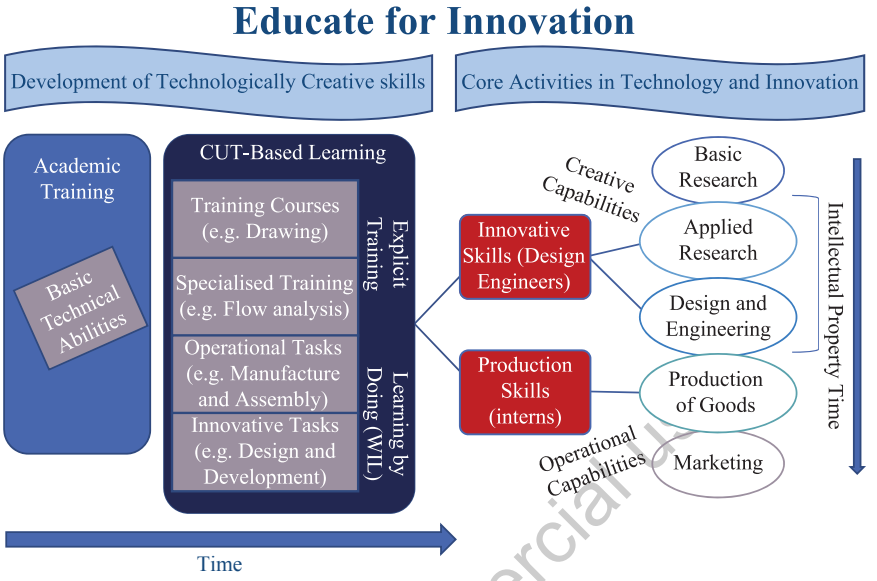
In the next section, the enablers to promote innovation and entrepreneurship education at the Central University of Technology, Free State (CUT) will be addressed.

Enablers for Promoting Innovation and Entrepreneurship at CUT

Innovation, as one of the precursors of entrepreneurship, is an important component of CUT's entrepreneurship education initiative. Although the profound difficulty of the local development, manufacturing and marketing of a product is well known, SA can no longer avoid empowering its citizens to establish manufacturing and other business enterprises. However, to do so successfully requires an innovative mindset and the necessary know-how, as well as considerable financial means. It is obvious that this changing situation requires a gradual shift in focus and effort from defining a problem, researching it and developing a solution to the problem. Figure 6 is a schematic representation of the process CUT is embarking on to academically prepare innovatively minded individuals to realise their possible capacity in the innovation domain (Jordaan, 2015).

Following the educational processes, as illustrated in Figure 6, the University approved the CUT Strategy for Innovation and Entrepreneurship in November 2015 to enhance regional competitiveness and wealth creation. The following ten (10) enablers have been embarked upon to promote innovation and entrepreneurship education at the Central University of Technology:

Figure 6
Educational Processes



Source: Jordaan, G.D. (26 June 2015).

1. **Accept innovation and entrepreneurship education as part of the integral and nuanced 'third mission'—or for emphasis—the fourth mission of CUT:** CUT has accepted innovation and entrepreneurship education as, for emphasis purposes, the fourth mission of CUT, over and above the current three missions of teaching and learning, research and community engagement. The nuance and connotation associated with the latter do not always allow the notion of innovation and entrepreneurship; hence, the extension to the 'fourth mission' to ensure that there is less inertia and competition. This will ensure that entrepreneurship education and innovation are considered as established parts of the University, over and above the normal engagement activities.
2. **An innovation and entrepreneurship curriculum:** One of the fundamental conditions for entrepreneurship education is in particular a progressive innovation and entrepreneurship curriculum. Without these being in place, the University would not produce entrepreneurs, but the regular graduates that we have been producing all along— some of whom are standing in queues looking for jobs (Mthembu, 2014, p. 21). CUT developed and implemented nine (9) new, innovative, demand-driven and user-oriented academic programmes through its Strategic Transformation of Educational Programmes and Structures (STEPS) process. Some of our graduates—those endowed with an entrepreneurial spirit and attitude— should be properly

nurtured so they could help to turn our dire socio-economic situation around. Furthermore, various formal education programmes, for example, a Master's Degree in Entrepreneurship, and short learning programmes, are under development. Some ad hoc entrepreneurial support programmes are already in place, such as the Innovation Week and the Start-up Weekend, and many of the programmes as mentioned above.

3. **Adopt an entrepreneurial pedagogy:** In order for CUT to ensure the successful implementation and promotion of entrepreneurship education, it had to adopt an entrepreneurial pedagogy. It is not so much about knowing as it is about doing—not what students know, but do; and not what lecturers know, but enable others to do (Neuvonen et al., 2015). Generally, this is precisely what UoTs say they are about that we now have to practise fully. In addition, new entrepreneurial teaching practices and methodologies are currently introduced, focusing on student-initiated learning. There is a vast difference between student-initiated learning and student-centred learning. The former is proactive on the part of the students, with some support lurking behind when needed. The latter may signal the benevolence of the lecturer in assembling material and adopting approaches that are more amenable to student learning; but, in a sense, with students taking less of an initiative for their knowledge. From the first day of lectures, students must be thrust into a real-life, and not a virtual, learning situation or environment (Mthembu, 2014, p. 22).
4. **Graduate attributes:** CUT adopted ten graduate attributes, two of which are innovation and entrepreneurship—as key elements for developing entrepreneurial graduates. The entrepreneurship attribute is about ensuring that graduates develop fundamental business skills, become entrepreneurial and industrious and are able to recognise opportunities and turn them into ideas for enterprises. The innovation attribute, on the other hand, encourages CUT students to be innovative, creative thinkers who apply a range of strategies to find solutions to real-world problems (Monnapula-Mapesela, 2015). These attributes are meant to instil a culture of innovation and entrepreneurship, even though not all of our students could actually become entrepreneurs. Some of them could still be intrapreneurs, innovating within their working environment. An intrapreneur is *an inside entrepreneur, or an entrepreneur within a large firm, who uses entrepreneurial skills without incurring the risks associated with those activities. Intrapreneurs are usually employees within a company who are assigned to work on a special idea or project, and they are instructed to develop the project like an entrepreneur would. Intrapreneurs usually have the resources and capabilities of the firm at their disposal* (Investopedia, 2016).
5. **Problem-based learning (PBL):** A central feature of problem-based learning (PBL) is that it is student-centred. Student-centredness dictates that learning opportunities should be relevant to the students. Creating assignments and

activities that require student input also increases the likelihood of students being motivated to learn. Hence, we have implemented such assignments and activities in several of our curricula. The context for learning in PBL is highly context-specific and serves to teach content by presenting students with real-world challenges (Smith, 2015). CUT's student-initiated pedagogy, as explained in (3) above, seeks to go further than student-centredness, beyond assignments and activities, to actual experimentation with the knowledge acquired in real-life situations.

6. **Design thinking and industrial design:** The design thinking process has seven stages: *define, research, ideate, prototype, choose, implement* and *learn*. Within these seven steps, problems can be framed, the right questions can be asked, more ideas can be created and the best answers can be chosen. The Department of Design and Studio Art was tasked to promote this learning methodology across the campuses, as it has a range of technologies available to consider solutions to problems.
7. **Work-integrated learning (WIL):** During WIL, students are placed with participating employers in commerce, industry and the public sector, with the aim to apply the theory that they have been taught in the practical work situation. In the workplace, students are in a position to identify problems, needs or gaps to be addressed, which creates an opportunity for the generation of solutions and ideas that can be turned into entrepreneurial opportunities. Therefore, creative and innovative ways to integrate WIL into the CUT learning process are explored, not only to expose students to outside classroom learning, but also to expose them to the authentic challenges and experiences of entrepreneurs.
8. **Service Learning:** Service Learning (SL) as pedagogy is recognised as a means of providing a dynamic and holistic education. It is grounded in University-community partnership projects. Service-learning projects '*combine needed tasks in the community with intentional learning goals and with conscious reflection*' (Kenworthy-U'Ren, McStay, & U'Ren, 2006, p. 170). Furthermore, social entrepreneurship is also promoted, which is the answer to the identification or recognition of a social problem and the use of entrepreneurial principles to organise, create and manage a social venture to accomplish a desired social change (Munsamy, 2015). The SL curricula in a number of academic programmes are currently revised in such a way that it focuses on entrepreneurial activities related to societal problems.
9. **Internationalisation as a tool to promote entrepreneurship education:** Campus internationalisation and long-term strategic, cross-border partnerships to promote entrepreneurship education and innovation in a multicultural and interdisciplinary fashion, are embarked upon. This includes facilitating the sharing of good practice in entrepreneurship education across borders, both within Africa and internationally; creating opportunities for students, educators and researchers from various countries to work together on projects, taking advantage of e-mobility and e-learning opportunities; providing

support for international mobility and the exchange of students, educators and researchers; and developing long-term partnerships with institutions with similar profiles and aspirations.

10. **Students should take centre stage in this strategy:** CUT is taking full advantage to empower students to drive the entrepreneurship agenda on campus; thus the student-initiated learning philosophy. From competitions to internships to student clubs, students are increasingly presented with opportunities to enhance and apply their learning outside the classroom through many different vehicles, in order to develop them as effective entrepreneurs.

These enablers are utilised to enhance the Innovation and Entrepreneurship Strategy at CUT, and they are the 'vehicles' integrated into the strategy. The Innovation and Entrepreneurship Ecosystem will be addressed in the next section of this paper.

CUT Innovation and Entrepreneurship Ecosystem

According to Jackson (2015), an innovation ecosystem comprises of important actors and entities whose functional goal is to enable technology development and innovation. The actors include material resources (funds, equipment, facilities, etc.) and human capital (students, staff, associate researchers, etc.) that make up the institutional entities participating in the ecosystem (e.g., partner universities, venture capitalists, funding agencies and policymakers). The innovation ecosystem comprises two distinct, but largely separated economies, the research economy, which is driven by fundamental research, and the commercial economy, which is driven by the marketplace. The challenge of creating growth in an innovation ecosystem is figuring out how to turn the breakthroughs of R&D into products that lead to profits. Achieving this is complicated by the fact that the two economies operate on different reward systems, thereby making it challenging to link discoveries derived from fundamental research with innovative products that can translate into profits in the marketplace.

However, by utilising the ten enablers to enhance the Innovation and Entrepreneurship Strategy at CUT, specific structures had to be implemented and well-resourced to promote a dynamic Innovation and Entrepreneurship Ecosystem at the University and in the region.

Structures and Initiatives Developed and Implemented at CUT

The following are a few structures and initiatives developed and implemented at CUT:

1. **CUT Idea Generator**
   This concept was approved by University Council, well resourced and is currently under construction at the Bloemfontein campus. The Idea Generator,

which will also host the FabLab that has been in operation for many years, is focusing on students from first-year level, staff, alumni and the broader CUT community. The purpose is to embed design thinking and problem-based learning by developing ideas, mostly linked to ideas of staff and students, and needs that are presented by society, and to find a way to develop these into innovative systems, processes or products to be successfully marketed.

The FabLab has become a support structure to CUT students, with various projects from their modules to enable them to develop ideas, projects and prototypes, which also contribute to their academic excellence. It ultimately ignites the spirit of innovation and entrepreneurship, as students start thinking of ideation and conceptualisation of their products beyond academic requirements. The FabLab also caters for non-CUT students, including high school learners and students from Motheo TVET College and the University of the Free State (UFS), as the aim is to reach the community as a whole in a quest to drive innovation across all age groups. One of the most interesting parts is an increase in the number of female students and learners making use of the facility. This shows a drastic transformation in the work that was primitively duped 'male dominated'. This significant rise in the number of female students and learners creates a path for prospective women entrepreneurship, which our country is so longing for.

Multi- and inter-disciplinary teamwork will be promoted, which should include elements of problem-based learning (PBL) and multidisciplinary teamwork. The CUT Idea Generator's objectives are as follows:

- to provide a vibrant environment that facilitates and catalysis innovative and entrepreneurial outcomes through collaboration brought on by dedicated facilities, strategic proximity and contemporary technologies;
- to avail an environment that solicits and supports creativity and design thinking;
- to provide an environment for CUT students, academia and other stakeholders to develop their ideas into products and processes;
- to maintain and expand networks between CUT and its quad-helix stakeholders; and
- to create knowledge and skills in the various areas of the innovation value-chain via both formal and short learning programmes.

2. CUT Incubator Programme

This programme, with two established incubators at both the Bloemfontein and Welkom campuses, supports SMMEs in two distinct phases, namely (i) virtual incubation and (ii) physical incubation, supplemented with a third (voluntary) phase (post-incubation support). Physical incubation support is provided for a maximum period of three years, during which time students should graduate and leave the incubation facility, with the intention of establishing their enterprises in facilities outside campus. During the

initial phase after graduation, the incubator management of CUT continues to support these enterprises in a virtual business accelerator for a period not exceeding six months. Currently, eight incubates are hosted in the incubator programme.

The CUT Incubator Programme is based on the following three core principles:

- focusing on nurturing and growing successful businesses—business and employment creation;
- operating towards a self-sustaining business. Initially, cost-recovery principles will apply; and
- offering a variety of services to incubator tenants, including training programmes.

The recruitment of the businesses to form part of the incubation is based on needs criteria, and a business needs to prepare a business plan to be scrutinised and analysed by the Technology Transfer Office. Upon incubation qualification, businesses are offered mentorship on how to effectively and profitably run their businesses. This is done through what is called Business Clinic Courses. These are the modules that capacitate the young entrepreneurs with information and resources at their fingertips, to cultivate the spirit of self-reliance. A mixture of various businesses, which makes an incubation process quite exciting, is currently incubated, to promote cross-disciplinary learning from each other. Some of the current incubated businesses, which include two black females, are as follows:

- Euodia Naanyane-Bouwer: The business manufactures washable sanitary pads for young girls who cannot afford them. The main aim is to ensure that girls do not unnecessarily miss school due to natural menstrual cycles that are beyond their control.
- Kamga Development and Enterprise: This is an emerging construction company doing work for CUT and the government. The owner is making strides in terms of growth, and ensuring that she learns as much as possible about the male-dominated business sector, in order to create a name as well as a client base for herself.
- E-Bitz: This company sells Arduino products and also supplies electronic components.
- NAHUL: This company is focussing on vacuum casting. It is one of only two entrepreneurs in the country doing vacuum casting.
- SAB KickStart. Ignite: CUT, as a partner of South African Breweries, has also incubated the second cohort of SAB KickStart Ignite participants. The programme is in its second year, and the incubation period is six months. Four young entrepreneurs occupy one office, which makes it easy for the Business Development Officer to effectively manage their incubation and to monitor their progress.

- Nosetsa: This incubatee, Mr Pontso Moletsane, the overall winner of 2015/2016 SAB KickStart Ignite programme/competition, created an irrigation control product that saves water through humidity-sensing techniques. He is now incubated for another six months to further develop the product with the prize money he has won.

The main challenges facing the CUT Incubator Programme are (i) that incubated businesses are too dependent on business originating at CUT and the provincial/local government. Securing business with government proved to be problematic where significant support is often promised to the businesses, but with no eventual roll-out of actual business. Incubated businesses need to be much more divergent in building their customer bases. Secondly, (ii) the lack of venture capital renders financial challenges for incubated businesses.

3. CUT Innovation Services

The CUT Innovation Services is a Trust. The Trust is the commercial arm of the University in which the University is the sole beneficiary. It is mandated to market, commercialise and solicit funding for the University's third-stream income initiatives, that is, intellectual capital through short course provision and management; fundraising (educational projects); applied research and innovation; and facilities management. Its focus is mainly on commercialisation of intellectual property and the establishment of an ecosystem for spin-off companies to receive the right support as part of the innovation chain.

4. Development of Programmes and Various Activities

Entrepreneurship in business is overwhelmed with very specific challenges, and also takes very specific personality traits. Before any successful programme can be launched, a full understanding and appreciation of the nature of entrepreneurs and the enabling environment is crucial. Various programmes and activities have been developed or are currently being developed, including the following:

- CUT Innovation and Entrepreneurship Week (two such events held in the past two years);
- entrepreneurship competitions amongst staff and students;
- working with academics to develop entrepreneurship foundation courses;
- hosting lectures on entrepreneurship;
- providing mentorship to staff and students wanting to be entrepreneurs;
- developing a mentorship programme whereby business leaders are allocated entrepreneurs/start-ups who need a mentor;
- identifying and facilitating technological and technical support, which CUT is in a position to offer;

- development of a pilot programme as a special Team Academy co-operative type for not more than 100 students, based on the University of JAMK's Team Academy in Finland;
- active involvement of student societies on campus; and
- hosting an annual CUT Seminar on Entrepreneurship Education (first conference organised for 5–7 April 2017).

5. Collaboration with External Partners

CUT has embarked on various strategies with external stakeholders to strengthen the Innovation and Entrepreneurship Ecosystem at the University and in the region. Some of these initiatives include the following:

- the establishment of the Regional Innovation Forum, Free State (RIFFS), with the current administrative hub situated at CUT;
- a Memorandum of Understanding entered into between the Mangaung Metropolitan Municipality (MMM) and CUT in 2015;
- the business plan developed for a Free State Science Park, in collaboration with UFS and other external stakeholders;
- the leading role by the Vice-Chancellor, with the support from the Premier of the Free State Province, to establish a high level *Task Team on Quad-Helix Partnerships in Promoting Regional Development and Economic Growth in the Free State Province, with the overarching goal 'To create a provincial factory for socio-economic development';*
- a Task Team initiated by CUT, in collaboration with the Free State Development Corporation (FDC), focusing on strengthening collaboration between all the relevant agencies, which include, inter alia, the FDC, Industrial Development Corporation, National Youth Development Agency, National Empowerment Fund (NEFCORP) and the Small Enterprises Finance Agency; and
- collaboration with the Technology Innovation Agency (TIA) and the National Intellectual Property Management Office (NIPMO).

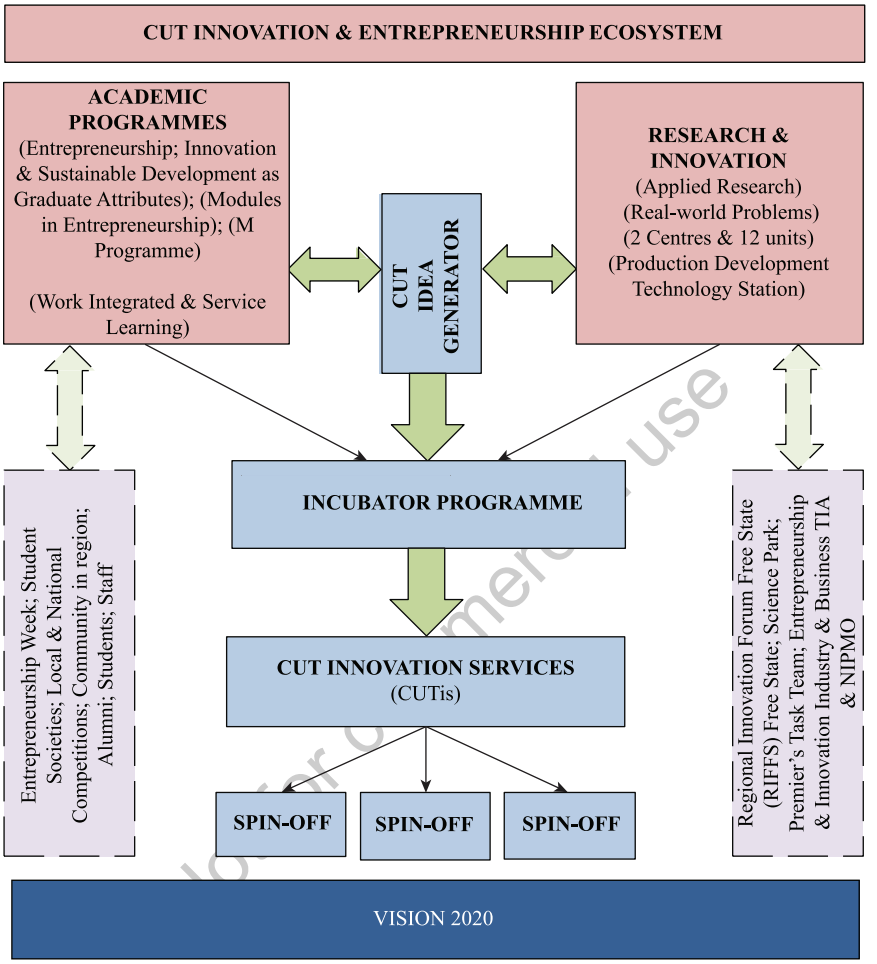
A number of existing projects are currently in the pipeline with these external stakeholders to strengthening the Innovation and Entrepreneurship Ecosystem at the University and in the region.

The CUT Innovation and Entrepreneurship Ecosystem is based on CUT's Vision 2020. Important external role players include the Regional Innovation Forum, Free State, Local and Provincial Government, Technology Innovation Agency, NIPMO and industry and business.

The Innovation and Entrepreneurship Ecosystem is illustrated in Figure 7.

The overarching challenge to ensure high impact and relevance is dependent on the development and successful implementation of an Innovation and Entrepreneurship Ecosystem, buy-in of all internal and external stakeholders, and dedicated resources to ensure the success thereof. The successes of these efforts at CUT are evident through the increasing national recognition of our innovation and entrepreneurship activities, of which a few examples are indicated in the following section.

Figure 7
Innovation and Entrepreneurship Ecosystem



Source: Authors' own.

Businesses Successfully Established

A number of businesses were successfully established during the past year, which include:

- *Tamikk Fatuku Sterilizer Company*, which was incubated in the CUT Incubator for approximately two years before it was spun out with the establishment of a factory in Bultfontein. The company manufactures sterilising products for domestic and other use.

- *Silver Flame Trading,* which was incubated in the Incubator for approximately eighteen months, opened an ITC shop supplying primarily HP equipment in Bloemfontein.
- *AddColour,* a software development company founded by two CUT students in 2015. They have developed a number of software solutions for SETAs, which include 'Careers' Guidance Application' and a 'SARS Rebate Application'.
- *SoftBrain Technologies* is an IT start-up business with three former CUT students as business owners. Their mandate is the development of mobile applications, computer software and Web applications.

Staff and Student Recognition at Regional and National Level

Examples of staff and student recognition at regional and national level over the past two years include the following:

- *SAB KickStart Ignite programme*: Student P Moletsane won the first prize in June 2016 and student M Mabaso the third prize. In addition, CUT has been selected as one of only four participating entities for the 2016/2017 cycle of the SAB KickStart Ignite programme.
- *Enactus CUT awards:* Enactus (Entrepreneurship Action and Us) is an international non-profitable organisation that brings together students, academics and business leaders who are committed to using the power of entrepreneurial action to improve the quality of life and standard of living for people in need. Enactus CUT won the 2014 Enactus Local Economic Development Special Competition Award; second place in the Absa Capacity Building through Effective Empowerment in 2015; second place in the Nedbank Triple Bottom Line Sustainability Competition in 2015; first place in the Nedbank Triple Bottom Line: Sustainability Competition in 2016; first place in the Harmony Gold Mine Entrepreneurial Approach Competition in 2016; and second place in the 2016 Enactus Local Economic Development Special Competition Award. In addition, Ms Maraka Lefera, a Master's student and Enactus CUT Co-Faculty Advisor, was awarded the Enactus South Africa Junior Alumnus of the year for 2016.
- *DST Women in Science Award:* Dr M Masinde, Head of Department of Information Technology, received the top award in the category Distinguished Young Women Researchers: Research and Innovation, at the annual Women in Science Awards function held on 11 August 2016.

The above-mentioned examples serve as testimony that the Innovation and Entrepreneurship Ecosystem has gained some momentum and demonstrated early successes, but more work is required to refine the system and to ensure full implementation.

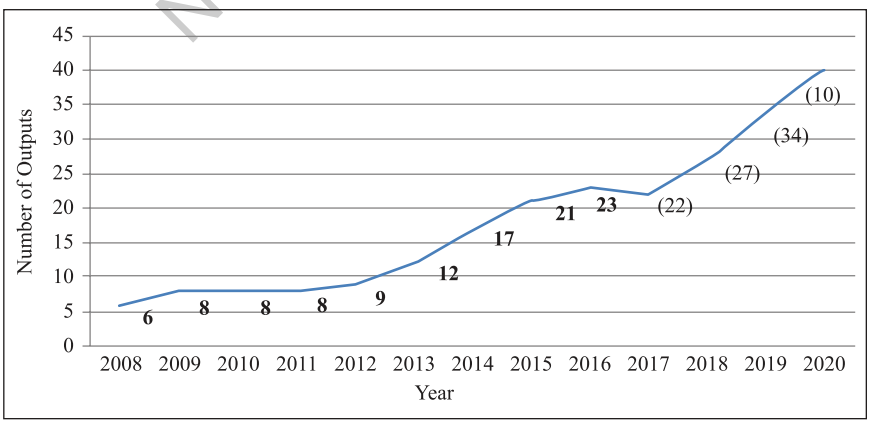
Knowledge Production at CUT

The Innovation and Entrepreneurship ecosystem, of which some elements thereof were implemented in 2012 already, had a substantial impact on the knowledge production from CUT over the past few years. The research programmes and entities at CUT were aligned during the past 5 years with the Research & Development Plan, which resulted in two Research Centres and twelve Research Units approved by Senate within three research clusters. This was done to strengthen the research base and knowledge production in order to enhance the innovation pipeline. Although CUT, being a pervious Technikon until 2003 focused mainly on teaching and started with a low research base, it is clearly illustrated in Figures 3 and 8 that the increase in research outputs since 2010 correlates with the innovation outputs since 2010. The last available data is for the year 2015 as the research outputs of universities in SA are accredited and approved by the Department of Higher Education and Training at year $n - 2$, meaning the universities received the confirmed outputs for 2015 in 2017 subsidy allocations. The planned trajectory as indicated in the Research and Development Plan is included for the years 2016 until 2020. The actual research outputs for 2015 were 17,048 weighted research outputs which even exceeded the target set for 2016.

Furthermore, a notable increase in post-graduate students were recorded during this period, for example, fifty-three masters' students graduated in 2016, compared to thirty-one in 2013 and nineteen doctoral students graduated in 2016 compared to three in 2013. The cumulative innovation outputs are illustrated in Figure 8, with the actuals of 23 in 2016 and the planned trajectory as indicated in the Innovation Plan for the years 2017 until 2020.

It is clear from Figures 3 and 8 that the increase in research outputs since 2010 and thus the increased knowledge production, has a direct impact on and correlates with the increase in innovation outputs.

Figure 8
Cumulative Innovation Outputs



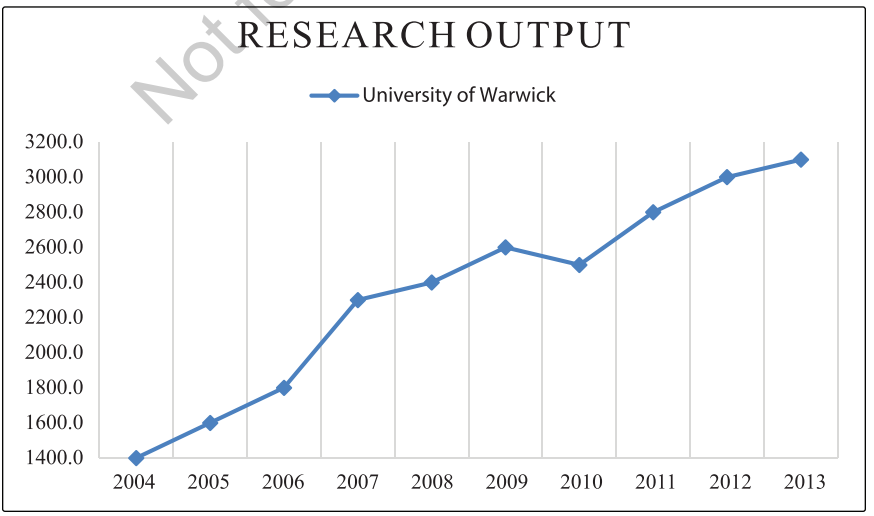
Source: De Jager. HJ. (2017).

The strategy of the Innovation and Entrepreneurship Ecosystem to transform CUT into an entrepreneurial university is in line with the developments at the University of Twente (UT), one of the leading entrepreneurial universities globally. The university management at UT made in the early 1980s a deliberate choice to play a key role in the rejuvenation of the region by engendering an entrepreneurial climate. Over the years, the university has progressively increased its knowledge exchange activities through research and teaching initiatives merged to the needs of local industry partners, the establishment of the technology transfer office, and the subsequent introduction of entrepreneurship education activities. The case study of the University of Twente focuses on the impact of the entrepreneurial university on the local economy in general and in terms of business start-up support and valorisation of research in particular. This valorisation strategy of the University of Twente has received recognition at national and international levels, as the University was voted in June 2013 the best Dutch university in the area of valourisation (i.e., translating scientific knowledge into social and economic benefits) (Heinnovate).

Furthermore, the University of Warwick is one of the UK's leading research-led universities with an acknowledged reputation for excellence in research and teaching, for innovation, and for links with business and industry. Founded in 1965, the scientific and technical capacity at Warwick has been recognised throughout Europe and across the globe as Warwick has been ranked as one of the top 100 universities in the world in the Times Higher Education World Reputation Rankings for 2015. (WBS, 2016). The achievements of this university are directly linked to its increase in research outputs, as indicated in Figure 9.

The University of Warwick, recognised as one of the leading entrepreneurial universities globally, with the University of Twente, has built a strong research base

Figure 9
Research Outputs for the University of Warwick



Source: Adopted from Carden (n.d.).

and knowledge production, to enhance its innovation outputs and being recognised as leading entrepreneurial universities.

The successes of these two universities form the building blocks of the Innovation and Entrepreneurship Ecosystem at CUT to transform the institution into an entrepreneurial university,

Conclusion

As was stated, SA needs new job creators to solve the job crisis. A new philosophy and approach to education in general are required; more specifically in a higher education sub-system of universities of technology in SA that is designed to lead to work opportunity enhancing outcomes. The Central University of Technology, Free State (CUT) has set a goal of transforming CUT into an innovation and entrepreneurial University and a robust agent for innovation and socio-economic development. The Innovation and Entrepreneurship Ecosystem established at the University, in the city and in the region, and the creation of an increasingly robust innovation and entrepreneurship pipeline and initiatives, are important building blocks of an innovation and entrepreneurial university. It is clear from this article that many other universities could pursue the path to innovation and entrepreneurship education with outcomes and impacts in broader society being firmly in focus. True to universities of technology's general philosophy of education, the path involves entrepreneurship education, research, idea generation and technology transfer. The overarching challenge to ensure high impact and relevance is dependent on the development and successful implementation of an Innovation and Entrepreneurship Ecosystem, buy-in of all internal and external stakeholders, and dedicated resources to ensure the success thereof. Such a system will undoubtedly impact on job creation to solve the job crisis, and to enhance socio-economic growth in the region and the country.

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