Universities of Technology – Deepening the Debate

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1 Quintin Brand Street
Persequor Technopark
Brummeria, Pretoria
South Africa
+2712 349 3840
www.che.ac.za

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10 Orange Street
Sunnyside
Auckland Park 2092
South Africa
+2711 628 3200
www.jacana.co.za

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Foreword

One of the more significant elements of the restructuring of South African higher education, during the past decade, was the change in the designation of those institutions known as technikons to universities of technology (UoTs). This change in name brought with it contested expectations of a change in the nature of these institutions. In 2006, the CHE published Kagisano 5: Universities of Technology which discussed the imperatives for change, the wisdom of this change in nomenclature, and what such newly conceptualised institutions could and should be.

In 2010, the universities of technology are an established part of the South African higher education scene. Debates about the need for, and wisdom of, the name change have given way to more pressing questions of how best to make the visions that were expressed for such institutions, translate into practice. This publication takes forward our understanding of the universities of technology, by fleshing out the issues and concerns that are being grappled with in these institutions.

This issue of Kagisano provides insider views of the universities of technology with papers contributed by senior staff working in the institutions. The eight papers cover key concerns – implementing appropriate teaching programmes, developing research in the institutions, the nature of technology transfer, the regulatory environment in which they operate and the monitoring of institutions' performance. The compilation of the papers was coordinated by the South African Technology Network and gives perspectives from across the sector with contributions from authors at five of the six universities of technology.

The Council on Higher Education supports a vision of a diverse higher education sector in which institutions position themselves in multiple ways in response to regional and national needs. The universities of technology, in taking the lead in debates about their positioning in the sector, and in tackling the challenges of operationalising their new positions, are making a valuable contribution towards realising this vision. Our hope is that this publication will contribute to deepening the debates about, and understandings of, the universities of technology and their contribution to higher education in South Africa.

Judy Backhouse
Director: Advice and Monitoring
Council on Higher Education

Universities of technology in the context of the South African higher education landscape

Prof. Roy du Pré

Introduction

This special edition of *Kagisano* is dedicated to providing readers with some insight into a new sub-sector in higher education in South Africa – universities of technology (UoTs). South Africa has not previously encountered such an institutional type in its history. This edition, and the articles contained therein, are designed to introduce the reader to the "new kid on the block", but at the same time to reinforce the academic credentials of this technology higher education sub-sector.

Universities of technology came into being as part of the major reconfiguration of the higher education landscape, which took place from 2004 onwards. Through a process of mergers and redesignations, South Africa's 36 higher education institutions (21 "traditional" universities and 15 technikons) were trimmed down to 23 – comprising 11 "traditional" universities (some of which were merged with others), 6 "comprehensive" universities (arising out of mergers between a traditional university and a technikon), and 6 universities of technology (created from 11 merged and unmerged technikons).

Universities of technology have as their foundation the former technikons which built a solid reputation in providing career-oriented programmes. These prepared graduates for the world of work. Their research was of an applied nature and their links with industry ensured that technikon programmes remained relevant, up-to-date, and that their graduates were familiar, through work-integrated learning, with the way industry functioned.

Throughout the world, universities of technology have made a major impact on the development of their countries and regional economies by preparing graduates for the world of work, and applying their research skills to identifying the problems and needs of society and industry, and together finding solutions to those problems. This edition of *Kagisano* provides an insight into the development, growth, direction and activities of a university of technology. It serves to emphasise that in the present higher education landscape, all universities in South Africa are equal – they only differ in their focus.

Background

In the latter part of the 19th Century, the development of railways and the discovery of diamonds and gold created a demand for artisans and skilled personnel to service these industries and services. This led to the establishment of technical and vocational schools and colleges. School education, and teacher, nursing and theological training, were largely the preserve of the churches and missionary societies. The establishment and development of traditional universities dominated much of the early part of the 20th Century, many of them arising out of technical colleges. The rise of apartheid in 1948 altered the educational landscape as the Nationalist government sought to structure schools and universities according to their racial ideology.

In 1967, the government recognised the need for higher level skills as the South African economy followed trends in the rest of the world.

Six Colleges of Advanced Technical Education (CATEs) were created out of technical colleges to provide such training. In 1979, this was taken further when these CATEs became "technikons", a new type of higher education institution offering career-oriented, post-school education. Technikons initially offered three-year post-high school national diplomas parallel to the first three years of a university. This was later followed by a national higher diploma on fourth-year level. In 1993, in a move considered radical in South Africa but in line with world trends, the government granted technikons degree-awarding status. As from 1994, technikons could offer, in addition to the three-year diploma, a fourth year resulting in a Bachelor of Technology degree (which replaced the National Higher Diploma) equivalent to the university Honours degree, as well as Master's and Doctoral degrees in technology. Yet, while technikons had in effect become "technical" universities by virtue of this change, they still retained the name "technikons".

In 1997, the Committee of Technikon Principals (CTP), a statutory body that coordinated the activities of technikons and advised the minister on matters affecting the technikon sector, began debating a name change. It was felt at the time that the nomenclature "technikon" did not adequately represent or identify a higher education institution.[1] There was a strong move to align the technikon sector with developments in the rest of the world where similar institutions/sectors had adopted more descriptive and specific nomenclatures, such as "University of Technology",[2] "University of Science and Technology,[3] "University of Applied Sciences",[4] "University of Cooperative Education",[5] "Institute of Technology",[6] "University of

1 The name "technikon" was unique to South Africa (a term invented by National Party politicians), the closest being a "technion" as used in Israel, and not recognised anywhere else in the world as a "university."

2 Notably in Australia and Hungary

3 Used in parts of Asia, Africa and the Middle East.

4 Generally used in Germany and Switzerland for the "Fachhochschulen".

5 Adopted by the Berufsakademien in Baden-Württemberg, Germany.

6 Largely used in the United States and the Republic of Ireland.

Professional Higher Education”,[7] or simply “university”[8] but defined by their Vision and Mission.

Because of the lack of unanimity within the CTP on the issue, the matter was dropped at the time. In 2000, the issue raised its head once again when the Council on Higher Education conducted a “shape and size” exercise which looked at a new configuration of the higher education landscape[9], and the CTP created a task team to advise the body on the way forward. The CTP Task Team developed a substantial and persuasive document, which clearly identified the need for a name change in line with trends in the rest of the world, provided compelling reasons for the adoption of the name “university of technology”, and spelt out a “philosophy” for a university of technology.[10] At a CTP workshop in February 2001, the CTP overwhelmingly accepted the recommendations and agreed to submit the document, along with a request to the Minister of Education to consider a change in name from “technikon” to “university of technology”.

After initial resistance from the Department of Education and certain quarters in the traditional university sector, the Minister announced in October 2003 that technikons would henceforth be known as “universities of technology”. The redesignation formed part of the reconfiguration of the higher education landscape, which at the same time provided for the merger of universities with universities, and universities with technikons. Some technikons were also to merge with other technikons, and those, together with unmerged technikons, would become a new and previously unknown university sub-sector.

In January 2004, Technikons Pretoria, Northwest[11] and Northern

7 Adopted by the Hogescholen in the Netherlands.

8 For example, in England and Belgium.

9 The CHE recommended stratifying higher education institutions on three levels: teaching institutions emphasising the undergraduate level; institutions offering a mix of teaching and research on under- and postgraduate level; “research” institutions specialising in postgraduate studies and research.

10 Position, role and function of Universities of Technology in South Africa.

11 Situated in Garankuwa in the North West Province.

Gauteng[12] merged to become Tshwane University of Technology; Vaal Triangle Technikon[13] became Vaal University of Technology; and Technikon Free State[14] became Central University of Technology, Free State. In January 2005, Cape Technikon and Peninsula Technikon merged to become Cape Peninsula University of Technology. In 2002, Technikons ML Sultan and Natal[15] had engaged in a voluntary merger and, despite the decision by the CTP to petition the ministry for the adoption of the term “university of technology,” took on the name “Durban Institute of Technology” (DIT). The decision by the Minister of Education to redesignate technikons as universities of technology left DIT out of line with the rest of the sector. In 2006, DIT changed its name again to Durban University of Technology, and in 2008 began to operate as a university of technology in line with the rest of the sector. Mangosuthu Technikon[16], which had earlier been earmarked to merge with DIT, remained unmerged and also changed its name to Mangosuthu University of Technology.

Technology higher education in South Africa

The six CATEs created in 1967 were situated in Pretoria, Johannesburg, Vanderbijlpark, Port Elizabeth, Cape Town and Durban. Programmes offered were at a higher level than those offered by technical colleges. The CATEs prepared graduates for the fast-growing industrial base such as:

- Iscor[17] in Pretoria and Vanderbijlpark;
- mining and manufacturing on the Witwatersrand;

12 Situated in Soshanguve, north of Pretoria.

13 Situated in Vanderbijlpark in the Vaal Triangle, Southern Gauteng.

14 Situated in Bloemfontein.

15 Situated in the Durban City Centre.

16 Situated in Umlazi, Durban, close to the airport.

17 Manufacturers of iron and steel.

- Sasol[18] in Sasolburg in the northern Free State (10 kilometres from Vanderbijlpark) and later Secunda, Mpumulanga;
- automotive, maritime, agriculture and related industries in the Eastern Cape;
- fashion, clothing, maritime, viticulture and fishing industries in the Western Cape; and
- automotive, maritime, mining, agriculture and tourism industries in Durban and surrounding areas.

The creation of the CATEs in 1967 did not appear to be sufficient to meet the growing demand for graduates with high-level skills allied to the sound academic foundation needed to direct and manage critical areas of a growing economy. In 1979, the six CATEs were redesignated technikons. Other technikons were also later established until by the late 1980s there were a total of fifteen in all. To support this growing but important technology higher education sector, the Committee of Technikon Principals was established as a statutory body to provide guidance and support, and to advise the Minister of Education on all aspects affecting technikons. In 1986, the Department of Education created SERTEC (Certification Council for Technikons), a quality assurance body for technikon education, the first such higher education body in South Africa. Technikons also promoted the concept of Cooperative Education, which was a partnership between the university, the student and industry and promoted the integration of academic studies with quality work-integrated learning. In order to support, promote and strengthen this key component of technikon programmes, the CTP established SASCE (the Southern African Society for Co-operative Education) in 1986. SASCE's mandate was to ensure the success of cooperative education where students are able to graduate with the competitive advantage of entering the world of work with accredited work experience, related to their qualification disciplines.

18 Processing coal for the production of fuel and the downstream products of oil.

The granting of degree-awarding status to technikons in 1993 was a recognition of the contribution this sector had made to the creation of a critical mass of graduates educated specifically for the world of work. Technikon qualifications were called programmes and not degrees, as was the case at traditional universities. These programmes were outcomes-based, that is, technikons first established what was required to prepare a graduate for a particular job, and then put together a suite of modules/courses which provided the candidate with the necessary skills, information, ability, training and wherewithal to "do the job". The granting of degree-awarding status also allowed technikons to prepare students to be managers, entrepreneurs and leaders in technology, and to enable them to engage in research in areas pertinent to technology higher education and industrial needs. While traditional universities engaged mainly in fundamental/basic/theoretical research, technikons on the other hand were involved in applied research – identifying the needs and problems of society and finding solutions thereto.

Once technikons became degree-awarding institutions, it was natural for the circle to be completed and the name changed to that of "university". In order for that to happen, technikons embarked on a drive to improve the qualifications of their staff, attract and increase postgraduate students, engage in applied research and grow their research profile and, finally, to change the designation "technikon".

Importance of technikons becoming "universities of technology"

The name "technikon", a uniquely South African invention, had been around for 25 years. It had taken a long time for the South African public to get used to the term, and in many quarters it had only become acceptable and recognisable in the late 1990s. Because a technikon was not a "university", it was considered inferior to institutions called universities; technikon graduates were not recognised by professional associations and the public service; and technikons were usually considered a second or third choice after universities.

With the onset of globalisation and the drive towards internationalisation, the name technikon became a stumbling block – technikons were not known to, or recognised by international associations, professional bodies, government educational institutions and learners. Membership of international university associations was denied, as technikons were not known as degree-awarding institutions of higher education.

Thus, no matter how widely technikons were regarded by industry and commerce because of the suitability and relevance of their programmes, and no matter what the extent and quality of their degrees were, they continued to suffer from the perception in the minds of parents, students, staff, the public service, Department of Education, government and the international community that they were inferior to universities.

Benefits of the name "university"

- With university status, a university of technology could ensure that its diplomas and degrees, and the graduates with these qualifications, obtained the recognition and credibility they deserved, particularly in the international arena.
- Recognition as a university would assist an institution in recruiting and retaining top-quality teaching and research staff, both locally and internationally.
- University status would improve access to funding, especially with respect to research grants and the funding of postgraduate programmes in high-cost categories.
- A university of technology would have a stronger appeal as an institution of first choice for local students, as a destination for international students, and an attraction for exchange and visiting staff.
- A university of technology would be recognised by national and international professional educational associations, organisations and agencies.
- Finally, universities of technology, as a consequence of the rapid development of an information-based society, would be in a better position to respond to the increasing quantum of knowledge needed for progress, by offering higher levels of learning through technically-infused programmes at the undergraduate and postgraduate degree level.

> By being redesignated universities of technology, the former technikons would be able to place themselves firmly in the minds of government, industry, parents and students as logical first-choice institutions of higher education. This would once and for all settle the problem of identity, profile and recognition which technikons had experienced with international, professional educational associations, organisations, agencies and students.

Defining a university of technology

What makes a university of technology different from any other university (as compared to the classical concept of a university)? It is not the use of technology within a university which classifies it as a technological university, but rather the interweaving, focus and interrelation between technology and the nature of a university, which constitutes a technological university. At a technological university the focus is therefore on the study of technology from the viewpoint of various fields of study, rather than a particular field of study. By "technology" is meant the human arrangement of nature with the help of tools for human purposes. Technology refers to the effective and efficient application of the accumulated know-how, knowledge, skills and expertise that, when applied, will result in the output of value-added products, processes and services.

In essence it is the know-how to fabricate things, which includes creating and developing new technologies. This concept finds its origin in the Greek word, *techne,* that means "skill" or "proficiency" and is also related to the words, *episteme*, meaning "understanding and skill", and *poeisis*, which denotes "working, creating" and, once again, "skills". Technology therefore straddles two issues: firstly, the skill to fabricate things and, secondly, the skill to manage the fabricated products. The understanding of technology in this document is closer to the definition by UNESCO:

> "*... the know-how and creative processes that may assist people to utilise tools, resources and systems to solve problems and enhance control over the natural and made environment in an endeavour to improve the human condition.*" (UNESCO, 1985)

The aim of technology then is to improve the lives of human beings. In relation to a university of technology it means that all teaching/learning programmes and research projects are related to technology. Technology is thus the qualifying factor inherent in all academic activities of a university of technology. In practice this means that although in principle all academic programmes should be studied at a university, this might not be the case at a technological university due to the nature of the different fields of study. At universities of technology, then, science, engineering and management would have top priority.

It is obvious that a university of technology will differ from a general university. Brook (2000) provides a useful set of characteristics of a university of technology:

- Research-informed;
- Curriculum developed around the graduate profiles defined by industry and professions;
- Focus on strategic research, applied research into professional practice;
- Multi-level entry and exit points for students;

- Concerned primarily with the development of vocational/professional education; and
- Technological capabilities as important as cognitive skills.

It is interesting to note (Klemm, 2004) that some "classical" universities, such as Oxford and Cambridge, do not offer engineering, for example, as a course, as they do not consider engineering "academic" enough. For them, the basic subjects are physics, mathematics, chemistry, etc., and engineering is the application of the combined basic sciences, and not a subject for a highly "academic" institution. These institutions only award BA degrees (no B.Sc. or B.Com. degrees) so graduates get a BA in Chemistry, for instance, showing skill in their chosen "art form". In contrast, technical universities around the world have economic advancement as their goal. They want to make things that work, and produce students who can make them work and make money as well. The Oxbridge approach is to develop learning that makes mankind feel good; making money is not in the equation.

In today's world, it has become important to make technology productive – in other words, to make money. Technology must make economic sense. Generally, science and engineering students come out of traditional universities with little understanding of the real world or, indeed, the world of work. They are skilled in the science, but are then faced with doing budgets, drafting strategic plans, writing reports, managing people, developing technology and applying skills. This is where universities of technology come into the frame. Clearly, a country needs both types of institutions, and each has its niche in its own spectrum of the country's educational requirements. Universities of technology become centres of technology excellence, and do not duplicate what traditional universities are so good at, and are geared to do.

Teaching technology at a university of technology implies an understanding of the application of the subject in the real world – such as designing and building a jet engine. Thus, there is nothing lower-grade about a university of technology. As an example: the PhD candidate from a university will be engaged in advancing mankind's knowledge by thinking about some of the unsolved challenges relating to space travel – in other words, philosophising until one hits on a new and uncharted piece of knowledge that needs resolution. So, the PhD will investigate the mathematics of how to send a spacecraft to another star, but the PhD does not actually know how to make the spacecraft. This is where the Doctor of Technology candidate at a university of technology comes into the picture: the one who will apply the findings of the PhD candidate and design, build and get the spaceship to its destination. There should be equal acceptance of both types of institution, degrees and candidates, because both have an equally important, complementary and symbiotic role to play in the development and advancement of mankind.

> Universities of technology aim at reality, which also happens to have a financial return for society as a goal. They proudly award master's and doctoral degrees which promote the message: "here is a person who understands life, and is not a backroom theoretician with little understanding of the real world". Universities of technology realise the importance of doing this job well and reaching the goal of becoming world-class: because that is actually the measure that counts.

Positioning universities of technology within a knowledge society

The emerging knowledge society has profound consequences for the university, regardless of its focus or specialisation. Conceptually three consequences can be identified:

- Firstly, universities have to accept the fact that they have lost their monopoly on knowledge development. The most innovative research and best laboratories are often found outside universities (for example, Silicon Valley). This new development forces universities to reconsider the way in which knowledge is being developed.
- Secondly, universities can sell their knowledge. In doing so, universities are acting like enterprises competing on the open market. This calls for universities to position themselves with regard to knowledge transfer.
- Thirdly, universities should deliver programmes contributing towards knowledge-based professions.

The way that universities of technology meet these demands is to direct the teaching and research programmes at meeting the needs of the society, but also to identify new possibilities for the knowledge society's development. The main focus is on creating a learning organisation through engagement with business and industry. Universities of technology serve as a learning laboratory for experimenting with new approaches and practices for the design and delivery of learning and research initiatives. The focus of these institutions would be to deliver on-site education and research enriched by industrial and business experience. The emphasis is to deliver employees ready for the world of work, and the curricula and research programmes are theoretical and application-driven. This kind of university brings the academic activities in close contact with the needs of the working place. Academic activities can therefore enrich the world of work. Universities of technology are becoming more effective in their managerial approaches and interaction with business and industry but they are careful that business principles should not be more important than academic paradigms.

Pillars of a university of technology in South Africa

There are five areas generally regarded as pillars of a university of technology:

- Excellence in teaching and learning;
- Applied research;
- Developing leadership in technology;
- Technology transfer and innovation; and
- Partnerships with industry (education for the world of work) and internationalisation (for benchmarking good and best practice).

Excellence in teaching and learning

Relevant higher education programmes

Because a university of technology must deliver appropriately qualified graduates to the labour market, they are therefore more closely allied to the business sector to ensure relevant curricula. This entails a continual revision of educational programmes at under- and postgraduate levels to better address the needs of industry, business and communities. This includes curriculum and course design linked to an outcomes-based type of education as well as to more flexible modes of delivery. The Teaching Factory concept at Nanyang Polytechnic in Singapore and the SUCCEED initiative between eight universities in the USA for first-year engineering studies are typical examples of such initiatives.

Flexible learning models

The utilisation of ICT (Information and Communication Technology) for a variety of flexible learning modes and online learning has broadened access to programmes of higher education institutions as part of a worldwide, life-long learning philosophy. This covers the total spectrum of distance learning (e.g. technology-enhanced) as well as a variety of modes used on campus as part of a course. For example, Virginia Polytechnic Institute and State University utilises the Virginia State network (Net.Work.Virginia) to offer courses at graduate level in Engineering and Business Administration.

Flexible learning makes the individualization of learning and

courses for a variety of prospective learners (such as mature, working persons) possible by means of wider access, recognition of prior learning and telematic learning methods. The innovative work done by Leicester University in the UK in the area of eLearning and on-line learning is changing the face of how higher education institutions engage with their students.

Entrepreneurial institutional culture

A new generation of innovative and entrepreneurial institutions have been established in recent years. Burton Clark (1998) identified and analysed five institutions in Europe as being very successful innovative and entrepreneurial institutions: University of Warwick in England; University of Twente in The Netherlands; University of Strathclyde in Scotland; Chalmers University of Technology in Sweden; and the University of Joensuu in Finland. Common characteristics include:

- A strengthened steering core with central faculty involvement and an administrative backbone that fuses new managerial values with traditional academic ones;
- A strengthened managerial core of agents who work to find resources for the institution as a whole;
- A lesser dependency on and greater autonomy from government;
- An enhanced development periphery where outreach units promote contract research, contract education and consultancy. These include new units and centres that are generally multi- or trans-disciplinary in nature. The institution moves into a matrix-type structure of basic units in which traditional departments are supplemented by centres linked to the outside world;
- A revised diversified funding base by the construction of a portfolio of patrons to share rising costs. As new patrons contribute, their expectations of what they should get in return readily intrude to become new constraints;
- Academic departments had bought into entrepreneurial change, even if the shift for social science departments (excluding economics and business) was more difficult;

- Successful entrepreneurial beliefs, stressing a will to change, can, in time, spread to become a new culture; and
- An organisational identity and focus to solve the problem of severe imbalances and to define anew their societal usefulness.

One must also take note of the entrepreneurial approach of the "land grant" universities in the USA and their commitment to their region/ local municipalities.

Emergence of centres for research and development (R&D)

There is a move towards the development of R&D centres of specialisation with common features, such as being multidisciplinary in nature; linked to a thematic approach in general; with the areas of specialisation directly linked to the needs of industry and business; and the participation of staff and students from various departments and faculties in the activities of the centre. These include educational programmes, R&D projects, industrial consultancy, innovation, incubation, technology transfer and product development.

Research and development centres are characterised by frequent interactions with business people, manufacturers, venture capitalists, patent lawyers, production engineers and researchers located outside the institution. R&D outputs may not always be reported in the traditional way through scientific conferences and journals and are sometimes confined to confidential reports of commercial sponsors, and patents and licensing agreements.

Establishment of institutional support structures

Effective institutional support structures are being established by such institutions for their revised role and for linking with industry and business. These support groups assist in the promotion and facilitation of projects and business development. The structures differ in order to accommodate specific needs of institutions. Examples are:

- International Relations and Business Development at Temasek Polytechnic;
- Innovation Centre at Nanyang Technological University; New Technology Development at Massey University in New Zealand;
- The Office of Technology Licensing at Stanford University; and
- Leuven Research and Development Unit at Katholieke Universiteit Leuven.

Work-integrated learning (experiential learning)

Work-integrated learning or experiential learning is a strategy of applied learning (learning integrated with work) which involves a structured educational programme that combines productive relevant work experience with academic study and "professional reflection". Embedded in the nature of technology higher education is compulsory experiential learning which provides students with relevant work experience. Students are required to undergo a period of on-the-job training as part of their degree studies. This period of work placement varies from a few weeks undertaken throughout the period of study, to six months, and a year in some programmes in the final year of study. The principal advantage is that students gain experience in a professional field during their formal studies and begin working life with knowledge of the marketplace, organisational structures and employers' expectations. Students are provided with practical and creative scope, and potential for advancement and personal growth in their chosen field.

The private and public sectors have consistently singled out the former technikons for their career-focused, hands-on approach to education and training and the delivery of graduates with knowledge that is immediately relevant in the workplace. The added advantage of experiential learning for both students and employers is that students "hit the ground running" when they enter the workplace. Employers do not have to waste time and resources training employees who only have theoretical background knowledge. Work-integrated learning will become even more important in university of technology programmes because of the growing demand and need in industry and commerce for graduates who are already familiar with the world of work before they are offered employment. Furthermore, it should be highlighted that graduates who are job-ready are in high demand with small and medium enterprises, since the latter do not always have the capacity nor the money to invest in experiential training or on-the-job training of graduates.

Career-oriented programmes

Degrees at a traditional university are expected to give students a grounding in, and understanding of, the basic scientific principles underpinning their field of study. On the other hand, programmes at universities of technology focus on the application of scientific principles in practice, and only use basic scientific principles in those cases where such knowledge is deemed to be essential to the successful application of the scientific principle concerned.

It is important to note that knowledge with a practical work-related orientation, which draws from multiple disciplines, can be segmented into subjects that have an internal coherence, the mastery of which equips the student with real skills. Additional subjects (many of which are multi-disciplinary) may be added, which can enhance the array of skills in the student's portfolio or increase the depth of understanding of scientific principles that form the basis of that specific career.

In career-/vocationally-focused programmes, students must have some mastery of the fundamental concepts and theories of the cognate disciplines upon which their knowledge field draws, while directing theoretical understanding to its application in practical contexts. Hence, both vertical expansion of complexity and horizontal expansion of skills are possible. The vertical expansion will, however, be specific and may be spread over several disciplines. The level of vertical expansion may in certain cases be higher than for traditional academic programmes. It is accepted that for each traditional academic discipline a so-called "body of knowledge" exists which needs to be mastered to a certain extent by the student.

In the same way, a "body of knowledge" can be associated with a specific occupation or career. This "body of knowledge" also contains a combination of applicable elements of academic disciplines. Because the "body of knowledge" required for successful career practice can fairly accurately be defined/determined and evaluated through inputs and interaction from that specific sector, the number of choice subjects will be severely restricted in career-oriented programmes. The opposite is true for traditional university courses where the variety of choice is fundamental to the development of intellectual curiosity and a sense of enquiry.

Research and development in universities of technology

The "research" university

Universities of technology acknowledge the world-wide negative impact on the higher education system caused by more and more institutions trying to adopt the culture and value system of "research" universities. In fact, many institutions claim a "research" mission, declare themselves "research universities" but are nowhere near the basic norms set for such institutions. With many institutions seeking or claiming this distinction, the public is understandably confused. The long-term result may lead to an erosion of the willingness to support or tolerate the research role of our most distinguished universities. Universities of technology are wary of falling into this trap by clearly defining what a university of technology should be, and what it should not be. At their present stage of development they make no claim to be "research universities".

There is a perceptible swing in public attitudes toward higher education that will place less stress on values such as "research excellence" and "elitism" and more emphasis on the provision of cost-competitive, high-quality services – that is, from "prestige-driven" to "market-driven" philosophies. While quality is important, relevance and cost are even more important. The marketplace seeks low-cost, tailor-made, quality services rather than "prestige". The public is increasingly asking, "If a Volkswagen will do, then why buy a Mercedes?" It could well be that the culture of "excellence" which has driven both the evolution of, and competition among, research universities for over half a century, will no longer be accepted and sustained by the general public, and that "new era" universities could well become the mode. It is, however, imperative that UoTs clearly know where they are going, what the prerequisites are, and most of all, what the expectations and outputs of such an institution are and should be.

While the unwritten social contract underlying the traditional government-university research partnership has always been based on the premise of practical benefits to society, it was also based on a linear model in which basic research successively led to innovation, development, production and societal benefit. In many cases this "linear" process was not so straightforward, and societal benefits were not so self-evident. There is no clear-cut distinction between basic and applied research, and in many cases commercial applications actually enable basic research. Institutions with a clearer ethos and mission towards innovation and development will form an invaluable ally and partner alongside the traditional basic research institutions. In the variety and scope of research approaches lies our country's future strength. The focus of a university of technology then will be mainly applied research and innovation, as well as on ways and means of solving specific problems that exist within commerce and industry. It is important to underline, however, that universities of technology do not aspire to be "research" universities in the form discussed above. The emphasis would be on teaching and learning, responsiveness and innovation.

The nature of research and development (R&D)

Prior to the restructuring process in higher education, which led to the reclassification of some technikons as universities of technology, the existing legislation categorised technikons as institutions

concentrating "on the application of scientific principles to practical problems and to technology and thus preparing learners for the practice, promotion and transfer of technology within a particular vocation or industry". The National System of Innovation proposed in the Science and Technology Policy requires that a set of functioning institutions, organisations and policies interact in pursuit of common social and economic goals. Given that some of the key objectives of this policy are to promote competitiveness and employment, and to improve the quality of life and work towards environmental sustainability, it is understandable that universities of technology, by virtue of offering training often linked to industry, are strategically placed to contribute significantly to innovation. This will remain a significant characteristic of universities of technology, as their core function will still be education and training in the career and professional stream. These institutions, apart from having close links with industry, will also need to be responsive to other societal needs. While recognising the importance of the complete continuum from basic research to commercialisation of research outputs, universities of technology will focus on research that is of a more applied nature (strategic and applied research), solving problems of society and the practical implementation thereof. This does not necessarily preclude involvement in basic research, as basic research provides the impetus for applied research.

Developing leadership in technology

An important characteristic of a university of technology is the relevance of its curricula and research programmes, which are related to the problems and concerns of industry, the community and society at large. These real-world problems are seldom neatly contained within the confines of any specific discipline. They are inherently complex in nature, cutting across a range of disciplines and requiring multidisciplinary teams to develop solutions. Usually there are many possible solutions to this type of problem, some more appropriate than others. Invariably technological choices have to be made.

It is the objective of universities of technology to educate and develop students who can engage effectively with real-world issues to the benefit of society at large, and not adopt a narrow focus and equip students only with technological competencies and practical skills to deal with these issues. Universities of technology therefore broaden their educational approach in order to expose students to a range of disciplines, including those from the humanities and social sciences, to enable them to make intelligent decisions and choices about a range of issues involving technology. For example, the exploration of Indigenous Knowledge Systems and its incorporation into the curriculum would be a core activity of universities of technology in South Africa.

Unprecedented changes, accompanied by unexpected opportunities and consequences, have been distinctive features of modern technology. While technology has brought with it unparalleled benefits, it has also had far-reaching implications, many of these undesirable. University of technology students must be in a position to appreciate the impact of technology on society, and understand the broader social, political and economic consequences of a particular technological solution. Technology is perhaps the most powerful agent affecting the environment. Technological development, particularly in the realm of biotechnology and genetics, has raised a number of ethical questions as well. It is necessary for students at universities of technology to be aware of the ethical and environmental implications of their technological choices, and to be able to determine the most appropriate solutions given the societal context. Students should be encouraged to think about the broader issues relating to technology. In this way they will not only be prepared for a more meaningful role in technology development and innovation, but for a far more responsible role in society as well.

With its strong focus on technology development, innovation and technology transfer, universities of technology would give attention to promoting a better understanding of these phenomena among their students. Topics relating to the management of technology, how it can be effectively used to create competitive advantage for the industry, and how technology interacts with other key business areas will also receive attention. While universities of technology will be actively engaged in technology development, technology transfer and innovation, it is also important that these institutions and the staff and students develop a deeper understanding of these processes, and how best to promote these in a variety of different contexts.

Universities of technology would therefore create opportunities in the curriculum for students to:

- reflect on the broader issues relating to technology, thereby generally raising their technological consciousness, and promoting a culture of technology at the institution;
- be encouraged to think about the impact of technology on society, in particular the unintended consequences of particular technological solutions, thereby enabling them to select the most appropriate solutions in a given situation;
- be exposed to a wide range of disciplines, including the human and social sciences, to provide them with a richer understanding of the world within which they operate;
- deal with issues relating to the management of technology, both within the industrial context as well as the broader societal context;
- gain a deeper understanding of the innovation and technology transfer processes, as well as the product development chain;
- work in teams, preferably multidisciplinary teams, around the solution of problems related to real-world situations; and
- discuss and debate technology policy and the implications this will have on the different sectors in society.

In this manner universities of technology will not only equip students with the high-level technical skills to engage effectively with real world issues, but will also educate students for leadership on the important technological issues facing society.

Technology transfer and innovation

Higher education institutions worldwide have realised the importance not only of generating new knowledge through research and development programmes, but also of participating actively in applying and utilising the knowledge and technology for new products, processes and services.

Entrepreneurial institutions have formulated and implemented strategies to ensure that the "flow through" of new technology into the market place actually occurs. The emergence of new modes of knowledge production, geared towards addressing the needs of government, industry and communities, as well as the need for higher education to stimulate economic growth, has led to revised strategies. In particular, a number of universities have opted for developing a community of skilled graduates with relevant and specialised knowledge and skills; contributing to a modernising economy through technological innovation and technology transfer, entrepreneurial development and the application of knowledge and technology; and stimulating economic growth and prosperity.

In the 2003 report of the International Intellectual Property Institute in Washington, USA, on technology transfer systems in the United States and other countries, the key role that universities play in national innovation systems was stressed. This role has traditionally been confined to training the human capital involved in R&D. However, universities are increasingly making a direct and substantial contribution to innovation, and thereby to regional economic growth, through the development of new technologies.

Both developed and developing countries are seeking to increase the contribution university R&D makes to national economic growth. This has led governments to restructure the institutional environment, usually through establishing clear intellectual property ownership policy in favour of universities, and by providing support programmes for the commercialisation of technology. In countries where this approach has been followed, universities take technology transfer seriously and have clear policies in place governing the

rights to intellectual property of inventions developed by them. Furthermore, the necessary support structures have been created to facilitate the commercialisation of university R&D, usually in the form of technology transfer offices.

Industry partnerships

Universities of technology, and the former technikons, have always been aware of the importance of industry-linking and partnerships. Institutions have realised both the potential and need for cooperation, partnerships and joint ventures with industry and business, linked to an entrepreneurial approach. This development ranges from formal education and training programmes and short courses, to research and development (R&D) projects and programmes. The success of Silicon Valley is directly attributed to the extensive linkages with four major universities. The Warwick Manufacturing Group of the University of Warwick plays a key role in the development of Warwick Science Park, a hothouse environment which nurtures high-tech companies. The University of Twente utilises the Twente Business and Science Park to ensure a vibrant economic development of the region. The Katholieke Universiteit Leuven, Belgium (KUL) draws on the expertise of the Leuven Research and Development Centre to maximise the research of its professors to identify, nurture and support spin-offs, and to establish and develop science and industrial parks as hubs for innovation and the commercialisation of academic and industrial research. Much of their activities are in the fields of microelectronics (arising out of the developments in semi-conductor research) and materials research and the potential and possibilities it has created, especially in the areas of medical science. The Eindhoven-Leuven-Aachen triangle (Eindhoven University, the Netherlands; Katholieke Universiteit Leuven, Belgium; and Rheinisch-Westfälische Technische Hochschule, Aachen [RWTH University]) have, in partnership with industry, created one of the top technology regions in Europe, in fact, in the world.

Practical contributions towards regional and economic progress

In contributing towards regional and economic development of the community they serve, an extended and revised role for higher education institutions has emerged. The UK Dearing Report (1997) strongly promoted the establishment of more technology incubator units within or close to an institution for the fostering of start-up companies and to support staff and students in taking forward business ideas developed in the institution. In the case of Silicon Valley in California it has been calculated that more than 1 500 companies have emerged as spin-offs from the work of staff and students from the engineering schools of Stanford University. The current value of the IT companies within this group exceeds $90 billion. In 1996, the sales from technologies licensed by academic institutions in the USA were estimated at $20.6 billion for that year. In 2007, the Eindhoven-Leuven-Aachen triangle contributed an added value of €32 billion and one-in-five jobs for their region. In Flanders, Belgium, the 325 companies created by KUL research and IMEC (a non-profit, independent R&D organisation established by the state government of Flanders in 1984) generated a turnover of €6 billion, creating 15 500 jobs in the Leuven region. In Leuven alone, the turnover from the 65 spin-off companies exploiting the university research of KUL totalled €600 million.

Internationalisation

As degree-awarding institutions, technikons after 1994 realised the importance of benchmarking with similar institutions around the world, for example, Australia, Germany, United Kingdom, Hungary and India in order to observe good and best practice. As universities of technology after 2004, these "new era" institutions in South Africa realised they were years behind in developments in this sector, but did not have the luxury of time to come up to their level. It was also unnecessary to re-invent the wheel. The only way to "fast-track" their

progress was to form partnerships, learn and observe, share best and good practice, and learn (and avoid) the mistakes made by others in their development trajectory.

> Universities of technology therefore set out to engage in partnerships with similar institutions around the world, and signed agreements with networks of similar institutions.[19]

Examples of outstanding universities of technology and their networks around the world

Australian Technology Network (ATN)[20]

The South African Technology Network of universities of technology concluded a partnership agreement with the Australian Technology Network in 2006 and signed the formal document in 2007. Technikons enjoyed a partnership with the ATN universities going back to the 1990s. The ATN is an influential alliance of five distinctive and prominent Australian universities located in each mainland State. The Australian Technology Network brings together five of the most innovative and enterprising universities in the nation. At the same time the ATN champions the principles of access and equity that have ensured its members are the universities of first choice for more students.

ATN is committed to forging partnerships with industry and government to deliver practical results through focused research, and educate graduates who are ready to enter their chosen profession,

19 In 2006, five universities of technology met to establish the South African Technology Network (SATN). SATN was formally constituted in 2007.

20 www.atn.edu.au

dedicated to the pursuit of knowledge and eager to claim a stake in building sustainable societies of the future.

ATN universities teach around 180 000 students, or almost 20% of Australia's student population. With one-in-four international students choosing to study at an ATN university, Australia's universities of technology are also the largest provider of international education, both with their onshore and offshore students.

The ATN's aim is to help secure Australia's reputation as the clever country, contributing to its social and economic wealth by building strategic partnerships and undertaking solution-based research which is relevant to the expectations of industry and the community.

International Strategic Technology Alliance (ISTA)[21]

The International Strategic Technology Alliance (ISTA) was founded in 1995. ISTA is an international collaboration and partnership platform among 24 renowned tertiary education institutions in China and around the world in fostering applied R&D, technology transfer and commercialisation of technologies and products. ISTA was established with great support from the Ministry of Education of China to leverage the expertise of renowned tertiary education institutions worldwide. It promotes intellectual exchange and cooperation among its member institutions in applied research and downstream commercialisation. It also provides an open platform for the exchange of best practices and enhances the international networking and collaboration of the members. ATN and ISTA are partners in the ATN-ISTA NanoNetwork.[22]

21 www.ista-net.net

22 www.lmbe.seu.edu.cn/nano

Duale Hochschule Baden-Württemberg (DHBW)[23]

Universities of Cooperative Education (formerly known in Germany as the Berufsakademie) have been a success story in the thirty years of their existence. In the state of Baden-Württemberg, there were eight universities of cooperative education operating across eleven campuses. On 1 March 2009, the German state of Baden-Württemberg changed the legal status of the Berufsakademien. The eight institutions are now collectively called Baden-Württemberg Cooperative State University, thereby raising the status of the institutions to ensure national and international recognition.

The Baden-Württemberg Cooperative State University, with its main seat in Stuttgart, is the first university in Germany to integrate academic studies and work experience. Its trademarks will be the structural characteristics of the Universities of Cooperative Education, in particular, the participation of training companies and institutions and the dual learning principle of studies. The eight main locations and three branch campuses with their areas of responsibility and close networking with the regional economy are the pillars of the Cooperative State University.

The conversion to dual university status means the new institution can grant academic degrees[24] in accordance with the Bologna Declaration.[25] One of the main innovations is the brief to realise cooperative research projects.[26] That means that collaboration with

23 www.dhbw.de

24 The Baden-Württemberg Cooperative State University offers a broad spectrum of bachelor degree programmes in the fields of business, engineering and social work.

25 The Bologna declaration of 19 June 1999 was a Joint Declaration of the European Ministers of Education providing for "easily readable and comparable degrees" on under- and postgraduate level. This provided an opportunity for the German system of the 4- and 5-year Diplom to be replaced by the British and American system of Bachelor, Master and Doctoral degrees. See http://www.magna-charta.org/pdf/bologna_declaration

26 Based on the concept of Cooperative Education also practised by universities of technology in South Africa.

partner enterprises and institutions can be intensified, and steps can be taken to make academic studies more up-to-date.

UAS7 – Seven German Universities of Applied Sciences[27]

UAS7 is a strategic alliance of seven leading German universities of applied sciences committed to excellence in teaching and research. The members of the UAS7 are the Universities of Applied Sciences in Berlin, Bremen, Hamburg, Cologne, Münster, Munich and Osnabrück. It was formed for the following reasons:

- Provision of well-established and future-oriented degree programmes "made in Germany";
- Commitment to programmes of professional relevance;
- Application-oriented courses; international perspective on a distinctly European and German basis;
- Efficient learning environments with small classes;
- Close relationships to the German business community; and
- Locations in major cities throughout Germany

Universities of technology have a partnership with German Universities of Applied Sciences going back a decade. In 2001, the Committee of Technikon Principals signed an all-encompassing agreement with the Hochschulrektorenkonferenz (HRK) [the German Vice-Chancellors Association] comprising all universities in Germany, and of which the universities of applied sciences are significant members in terms of numbers and influence. The HRK recognised all technikon qualifications and this provided for any technikon graduate being given equivalent status to any German graduate, and entrance to the next level of study at any German university. The recognition by German universities of technikon and other South African graduates

27 www.uas7.org; www.wikipedia.org/wiki/UAS7; interview with Prof. Mielenhausen, Rector, University of Applied Sciences, Osnabrück, Germany, 29 May 2009.

provided the catalyst for recognition of technikon and other South African qualifications by the rest of the world. SATN is in the process of signing a partnership agreement with the UAS7[28] and also has individual partnership agreements with individual universities of applied sciences.

Swiss UAS (Bern, SUPSI, Zurich)

The Swiss Universities of Applied Sciences occupy a special place in Swiss education, culture and the economy. The majority of Swiss students (around 80%) from Grade 10 onwards complete the rest of their high schooling at a technical high school. (In contrast, the percentage in South Africa is negligible.) So, when they complete Grade 12 and want to enrol for higher education, the logical place for that 80% to follow up the technical education they received from Grade 10-12, is at technical universities, which in Switzerland are the University of Applied Sciences. The results are for all to see – Switzerland is the richest country in the world. Its citizens have the highest per capita income in the world. The list of manufacturers, innovators and products produced by the Swiss is self-explanatory: high-precision tooling, high beam research, biomedical research and manufacturing, chemistry, construction, computers, food, Swiss machines, precision turning and boring tools, rotary-broaching materials, thread-whirling spindles, banking and investments, not to mention Swiss watches, Swiss knives and Swiss chocolate. Notable companies that come to mind are pharmaceutical giants Novartis and Bayer, and Brown Boveri (railway diesel/electric trains and rolling stock).

28 On 29 May 2009, the chairperson of the SATN, Prof. Roy du Pré, began preliminary discussions towards concluding an agreement.

Examples of outstanding and innovative universities of technology

Universities of technology (and the former technikons) have since 1994 benchmarked with a number of universities of technology at various levels in various parts of the world. Many of these partnerships are still on-going and have been of great benefit to both sides. Among them have been and still are the following:

University of Warwick

The Warwick Manufacturing Group of the University of Warwick plays a key role in the development of Warwick Science Park, a hothouse environment which nurtures high-tech companies. Because of its closeness to Coventry the home of Jaguar, Warwick had for years played a critical role on the success of Jaguar cars.

University of Twente

The University of Twente utilises the Twente Business and Science Park to ensure a vibrant economic development of the region.

Katholieke Universitiet Leuven (KUL) and Eindhoven-Leuven-Aachen Triangle

The Katholieke Universiteit Leuven, Belgium (KUL) draws on the expertise of the Leuven Research and Development Centre to maximize the research of its professors to identify, nurture and support spin-offs, and to establish and develop science and industrial parks as hubs for innovation and the commercialisation of academic and industrial research. Much of their activities are in the fields of microelectronics (arising out of the developments in semi-conductor research) and materials research and the potential and possibilities it has created, especially in the areas of medical science. The Eindhoven-Leuven-

Aachen Triangle (Eindhoven University, the Netherlands; Katholieke Universiteit Leuven, Belgium; and Rheinisch-Westfälische Technische Hochschule, Aachen [RWTH University]), have, in partnership with industry, created one of the top technology regions in Europe, in fact, in the world.

The SATN has an especially close relationship with KUL in the area of technology transfer and innovation.

Limerick

The University of Limerick (UL) was established in 1972 as the National Institute for Higher Education, Limerick, and classified as the University of Limerick in 1989. The University is an independent, internationally focused university with over 10 990 students and 1 313 staff. It is a young, energetic and enterprising university with a proud record of innovation in education and excellence in research and scholarship. Its mission is to promote and advance learning and knowledge through teaching, research and scholarship in an environment that encourages innovation and upholds the principles of free enquiry and expression. Particular attention is paid to the generation of knowledge which is relevant to the needs of Ireland's continuing socio-economic development. Cooperative education and the relationship with industry is an especially strong characteristic of the university.

UL offers a range of programmes up to doctoral and postdoctoral levels in the disciplines of arts, humanities and social sciences, business, education and health sciences, science and engineering. Adjacent to the University is the National Technology Park (NTP), Ireland's first science/technology park (263 hectares), which is home to over 80 organisations employing over 4 000 people. There is a close interaction between UL and the National Technology Park. The National Technology Park has been designed to meet the needs of high-technology and knowledge-based businesses by providing low-density development in a high-quality parkland environment.

The park provides a range of flexible business infrastructure and accommodation options for eligible activities.

Universities of technology have visited and benchmarked with UL since the 1990s, the last being as recently as April 2009.

Indian Institutes of Technology

The Indian Institutes of Technology (IITs) are a group of 13 autonomous engineering and technology-oriented institutes of higher education established and declared as "Institutes of National Importance" by the Indian government. The IITs were created to train scientists and engineers, with the aim of developing a skilled workforce to support the economic and social development of India after independence in 1947.

Some IITs were established with financial assistance and technical expertise from UNESCO, Germany, the United States, and the Soviet Union. Each IIT is an autonomous university, linked to the others through a common IIT Council, which oversees their administration. They have a common admission process for undergraduate admissions, using the Joint Entrance Examination to select around 4 000 undergraduate candidates a year.

The degrees provided by IITs are recognised by all institutions in India. Even outside India, IIT degrees are respected, largely due to the prestige of the IITs as created by their alumni. One of the contributing factors behind the success of IITs is the special status of the IITs as Institutes of National Importance under the Indian Institute of Technology Act. The IIT Act ensures that the IITs have special privileges and lays the foundation for them to evolve as world-class institutes. The autonomy ensured by the Act enables the IITs to implement changes quickly, to keep up with changing scenarios in both the educational world and society in general. Student politics in IITs is kept under control with strict vigilance over the way student body elections are held. The IITs are allowed to accept only a select

group of meritorious students. This combination of success factors has led to the concept of the "IIT Brand". Other factors that have contributed to the success of IITs are stringent faculty recruitment procedures and industry collaboration. The PhD degree is a pre-requisite for all regular faculty appointments. The IITs have better interaction with various industries as compared to most other Indian colleges. The IITs are also considered highly successful institutions compared to other engineering colleges in India according to a number of educational surveys.

The view that IIT graduates are intelligent and hardworking people has been established by the success of IITians. Former IIT students apparently get greater respect from their peers, academia and industry in general. The IIT brand was reaffirmed when the United States House of Representatives passed a resolution honoring Indian Americans and especially graduates of IIT for their contributions to the American society. Similarly, China also recognised the value of IITs and plans to replicate the model.

Technikons in 2001 and the universities of technology since then have forged close ties with the IITs and have benefitted from their model, practices and expertise.

Conclusion

Universities of technology in South Africa largely echo the technology higher education institutions indicated above in their vision, mission, objectives, distinctive approach to research, relationship to and with industry, technology and knowledge transfer, access and career-oriented academic programmes. Excellence in teaching and learning, preparation of students for the world of work and developing leadership in technology take priority. However, because universities of technology as higher education institutions are little known in South Africa, they still have a way to go simply for South Africans to get to know them, understand them, accept them, study with them, employ their students and recognise them as universities equal in status to any other institution in South Africa. The technikons, at the time of their demise, were well understood and well accepted, especially by industry, who found their students highly employable. Students too had come to realise that their chances of getting a job with a technikon qualification were greater than with an ordinary university degree. That brand has been lost and the challenge is to get universities of technology to the same level of awareness as quickly as possible. Above all, it is important to get everyone to realise and accept that in the present higher education landscape, all universities in South Africa are equal – they only differ in their focus.

Universities of technology in South Africa are well on their way towards becoming first-choice institutions for: school-leavers wanting a practical, career-focused university qualification; adult workers needing recognition of their prior learning and experience and being able to move on from there; and industries looking for graduates with practical, hands-on experience, who can "hit the ground" running when they enter the workplace.

This journal is dedicated to articles from staff in South African universities of technology to provide the reader with an indication of the kind of work (teaching and learning, curriculum development, research, technology transfer, quality assurance, etc.) presently undertaken in South Africa's universities of technology.

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Case studies in research capacity-building initiatives

Dr Karin Dyason, Prof. Laetus Lategan and Dr Tembeka Mpako-Ntusi

Abstract

This article presents three case studies on research capacity-building initiatives. The capacity-building initiatives are necessitated by several factors such as the development of emerging universities of technology and a large pool of novice researchers who must be developed into established researchers. Both the emerging universities and novice researchers' capacity for research activities should be increased in order for these universities and researchers to participate in the full range of challenges associated with research.

In conclusion, important lessons are drawn from these case studies, which can serve as a guide and a benchmark for research capacity-building.

Introduction: national imperatives and institutional responses

The dynamic character of higher education in the 21st Century and relatively recent changes within the South African higher education landscape have presented a number of challenges. These changes

include growth in the number and diversity of students, a focus on new knowledge, research and knowledge transfer, the emergence of different teaching and learning delivery methods (including a mix of e-learning, practice-based learning, and tutor-led learning). To this list may be added the enhancement of quality and standards (both as measured institutionally and through individual performance), effective leadership and management, and increasing professionalisation. In particular, with regard to research, the researchers and research management at universities (of technology) in South Africa are facing many challenges. These challenges range from growth in research outputs (publications and postgraduate qualifications), transferable research skills, co-operation with business and industry, relevance of research, access to state of the art equipment, retention of researchers, and the development of a new generation of researchers.

Following on these challenges, all universities (of technology) have introduced strategies to promote and sustain their research activities. At universities of technology (UoTs) the strategies are especially directed at developing capacities to deal with the challenges associated with an emerging research culture. Some of the driving forces behind this emerging research culture are the 1993 Technikon Act that mandated technikons to award degrees and postgraduate qualifications with a research focus, the South African Research and Development Strategy, the Higher Education Quality Council (HEQC), the rating system of the National Research Foundation (NRF), and the transformation of technikons into UoTs.

> In this contribution the authors will reflect on some strategies implemented at three universities of technology to deal with the challenges of an emerging research culture.

Reflection on institutional strategies

1. Cape Peninsula University of Technology

The mandate of Research Management is to provide research support to staff and postgraduate students, the ultimate purpose being the promotion of scholarship and the production of research outputs. Achieving this purpose is hindered by several factors, including the history of universities of technology. One of the interventions identified by Cape Peninsula University of Technology (CPUT) for addressing the many challenges confronting UoTs is the development of a research culture, and the empowerment of researchers at all levels through the following research capacity development interventions.

1.1 Research capacity development

The CPUT Research Capacity Development Programme is aimed at building a research culture through the following interventions:

Support for emerging researchers

This group consists of inexperienced researchers who are busy with their doctoral studies or have recently graduated and are planning research projects as part of developing their academic careers. Support for this group features interventions such as career planning, proposal writing and writing for publication. Emerging researchers need guidance in planning their academic careers. Research activity leading to publications is essential, while presenting research results in peer-reviewed conferences provides the opportunity for peer reviews, collaborations and partnerships. The networking that takes place during these conferences exposes emerging researchers to global experts and others interested in similar research issues.

One of the greatest weaknesses of emerging researchers is the ability to write meaningful research proposals that show a clear research design and methodology, and succeed in attracting financial support from internal and external funding sources. Research Management should not take this skill for granted, but should actively inculcate it as part of empowering researchers to do and be the best that they can be. Very few academics are born with a natural talent for systematic scholarly investigation that leads to discovery or innovation. Most academics have to be nurtured into the research practice and habit.

Writing for scholarly publications is another skill that most emerging researchers lack. It has become evident that research capacity development interventions have to focus on this area in order to enable researchers to publish their findings in accredited and peer-reviewed publications. CPUT takes this intervention seriously as one of those activities that will improve both the quality and the quantity of research outputs from the institution. Several workshops and training seminars are arranged and presented focusing on each of these interventions directed at emerging researchers.

Support for mid-career researchers

This group consists of researchers who have a doctorate and are engaged in research in order to enhance their academic career. The major goal of this intervention is assisting researchers to apply for NRF rating. Workshops are arranged towards the end of the year when the call for rating applications is uploaded by the NRF. The purpose is explaining the whole procedure to the potential applicants, and taking them through the online application system. Another workshop is arranged early in February in order to assist those researchers who intend to submit their rating applications by the end of February. This has been found to be helpful because some researchers are discouraged by the online application process due to the technological challenges involved in using the electronic system. Working in a group, with adequate support from the Research Department, has enabled some researchers to persevere with their applications up to submission stage.

Support for established researchers

Established researchers who have varied levels of experience with successful projects are offered seminars on subjects such as project management, finance management, good practice in research focusing on ethics, and ways of identifying research findings that have a commercialisation potential. With Technology Transfer being promoted at the UoTs, it has become indispensable to give guidance and support to researchers to make that transition and to know when there is intellectual property to be protected or a patent to be registered.

Support for postgraduate supervision

One of the critical skills for promotion of scholarship and production of research outputs is the supervision of postgraduate students. This is not a role that academics can decide to perform as they wish. There are institutional guidelines for good practice, minimum standards to be upheld, compliance issues and sometimes legal contracts involved. All academics involved in postgraduate supervision deserve adequate preparation and support in order to perform properly in this role. CPUT has an established Higher Degrees Committee that monitors postgraduate studies. It is important for the Research Management to provide the necessary support.

Support for technology transfer and research commercialisation

The current trend for universities is to go beyond research reports to commercialisation of research results. Since this is not something that comes naturally to researchers, it needs to be cultivated and nurtured. CPUT has recently established a Technology Transfer Office and the positions of Director for Technology Transfer and Manager for Commercialisation have been created. Researchers definitely need adequate support to make the transition from research to commercialisation. This programme caters for that need as well as for the general motivation of researchers to plan their projects to go beyond publication of results to the production of services and artefacts. One of the major prescriptions of the National Plan for Higher Education (NPHE) (2001) is that universities should conduct research that has social impact and contributes to the economic development of the country.

Mentoring

An academic career is just like any other profession. Its expertise is generated from experience that comes from years of engagement in scholarship and related academic activities. Young scholars or academics benefit from being mentored by experienced scholars who play the role of being a coach or career guide/companion that the inexperienced party can consult when necessary. CPUT has aligned itself with the NRF programme that uses mentoring as a research capacity development and empowering process. Twinning an emerging researcher with an established researcher of their choice is encouraged and will be monitored for its effectiveness in achieving the goals of the programme. The guiding principle in this intervention is voluntary participation and the choice of a mentor that appeals to the inexperienced researcher. The research manager driving this intervention assists in drawing formal and informal contracts, and measuring the achievements of goals identified by the mentoring partners. A detailed annual schedule has been drawn, and it is hoped that the impact of these interventions will be reviewed periodically.

Structures and systems

CPUT has developed several structures and systems for the implementation of this research development programme. For example, each faculty has a Faculty Research Committee, a sub-committee of the faculty board, led by a coordinator who reports to the dean of the faculty. The deans and coordinators form part of the Senate Research Committee that meets on a quarterly basis. The major function of the Senate Research Committee is to coordinate, monitor and guide the entire research enterprise in the institution.

Several policies, guidelines and terms of reference have been developed. The implementation is monitored by the Senate Research Committee. The entire research enterprise is funded by the institution through a University Research Fund (URF) of which the budget is managed and administered by the Research Department.

2. Central University of Technology, Free State

2.1 Scientific writing

In the South African higher education system, research articles in accredited journals and completed Masters and Doctoral studies are regarded as research outputs. State subsidy for research is earned on the basis of these outputs. A range of policies and initiatives support the drive towards an increase in research outputs – both in qualitative and quantitative terms. Examples are: the NPHE (2001); the Academy of Science of South Africa's *Report on a Strategic Approach to Research Publishing in South Africa* (2006); and the National Research Foundation's Vision 2015 (2007), etc.

Several universities have taken on different strategies to meet the expected research outputs. Normally, these strategies are part of universities' ongoing promotion of a research culture. At the (new) universities of technology this is no lesser activity. The Central University Technology, Free State (CUT) is mindful of the fact that the former technikons were given permission to award degrees approximately 15 years ago. A research culture characterised by research outputs is therefore still emerging. A fundamental approach to research at the CUT is directed at the development of a sustained, engaged and responsive research culture. Five activities are associated with the development of research:

- Firstly, a research culture driven by an approved Research and Development Plan;
- Secondly, the development of staff as researchers;
- Thirdly, the training of postgraduate students as future researchers;
- Fourthly, engagement with government, business and industry; and
- Fifthly, the conceptualisation of a research framework that includes the pillars of discovery (basic research and innovation) and integration (applied research, tech transfer and commercialisation).

All these activities are informed by the NPHE (2001), National Science and Innovation strategies and the CUT's corporate strategic initiatives.

A particular approach to research and development at the CUT is the approach of *intellectual* and *structural capacity-building initiatives*. Examples of structural capacity-building initiatives are committees such as a Central Research Committee, Faculty Research Committees, a Research Forum, a Grants Committee and a Postgraduate Committee. Examples of the intellectual capacity-building initiatives are workshops on the research process (such as scientific writing, postgraduate supervision), mentorship programmes, research group meetings and an in-house journal to provide novice researchers with the opportunity to get introduced to the process of scientific writing and publication.

This section will reflect on the intellectual capacity-building initiatives expressed in scientific writing.

The CUT identified two activities in support of the development of a scientific writing culture and to create an enabling environment for scientific practice:

- Workshops on scientific writing; and
- In-house research journal to support scientific writing culture as part of a research culture.

A module on scientific writing was developed, and the various parts thereof are discussed during workshops. The module on scientific writing consists of understanding the structure associated with scientific writing, self-assessment of scientific writing and work sessions to evaluate progress. The proposed structure emphasises the structured approach thereto and consists of: title; abstract; introduction; identification of methodology/ies; body or content (literature review); qualitative/quantitative study; results and discussion; conclusion; references; appendices; and key concepts (see Lues and Lategan, 2006). Various forms of review may be identified. In this section the focus is on a structural, critical and value-adding review (Lategan, 2008).

2.2 In-house journal

Interim (ISSN 1648-498X) is an in-house research journal published twice a year. The goal of the journal is to give novice researchers the opportunity to publish their research and established researchers to publish work in progress. These articles are all peer-reviewed to expose researchers to the process of peer review. An in-house peer review approach is followed with the main emphasis on improving the quality of the article, the building of self-confidence in the art of publication writing and the mastering of skills and techniques associated with publication writing.

The first edition of *Interim,* an interdisciplinary in-house journal, was published at the end of 2002. The journal is now in its eighth year with bi-annual editions. Its main objective is to enhance the research culture at the CUT through scholarly publications. The journal provides researchers – both staff and students – at the CUT with the opportunity to publish research in progress. The idea of this journal is to encourage academic dialogue, to create a culture of scholarly and interdisciplinary work and to give novice researchers the opportunity to publish their research. The articles are all peer reviewed and general errors and challenges associated with publication writing are explained at a workshop before each edition of the journal is finalised. This method exposes novice researchers to a culture of publication. An important drive behind this initiative is to prepare staff and students to publish in accredited journals and to overcome the psychological hurdles associated with publications (anxiety/fear of rejection, peer pressure, not scholarly enough, etc). (More information on *Interim*, its guidelines and aspects of the review process can be obtained from http://www.cut.ac.za/web/academics/acadsup/Research/publications. Online editions are available.)

2.3 Reflection

Table 1: *Interim* publication categories 2002–2008

Category	Numbers
Number of editions	13
Number of authors	266
Number of papers	153
Number of student contributions	33
Number of external research partners co-authoring articles	34
Number of published papers in accredited journals	30

From a closer analysis of this data one can state that the thirteen editions in seven years are evidence enough that this model is high in demand and that both staff, students and external research partners are eager to participate in this initiative.

It should also be appreciated that more than 12% of students and close to 13% of the external research partners contribute to the total number of 266 authors, and more than 21% of students and just more than 22% of the external research partners contribute to the 153 papers published since the first edition. The student participation should not be understood free from the context that many of the senior students are appointed on the staff establishment. Although this is a journal directed at the CUT community, external partners (as supervisors, research associates, etc) co-author these papers as part of the joint research venture. This is interpreted as a positive association with the university's research and the capacity development driven by this journal.

On average just more than 1.7 researchers contribute towards the 153 papers. Three observations must be noted. Firstly, more than 10% of the authors contributed more than once to the journal, which is a positive indication of the value of the journal. Secondly, multi-authored papers signal that senior authors involve novice researchers in publishing articles. Thirdly, single-authored papers are evident of independent scholarly contributions.

Another objective of the journal, namely preparation for accredited articles is also on the move. Close to 20% of the *Interim* articles are already published in accredited journals. It should be noted that it is not always the same paper published in *Interim* but often a revised, a combined or multi-authored article.

Interim undoubtedly contributed towards a scientific writing culture as part of a broader research culture. Value-added activities include the exposure of internal staff members to editorial work from the call of papers to the technical process of getting papers printed. For two editions, staff acted as guest editors of the journal. Other value-adding activities include showcasing of a practical model to develop novice researchers – this can rightfully be regarded as a model for scientific writing incubation. It is also notable that the journal provides a home for (seasoned) researchers' research work in progress. Although this was not initially the purpose of the journal, is it possible to accommodate this need within the journal. The stimulated environment also positively contributed to the sustained group of researchers compared to the previous ten years.

Another positive reflection is that *Interim* is available on-line and in hard copy. The journal is not only used as a marketing tool but also as science reference. It is notable that the editorial teams through the years have positioned this journal as strategic mechanism to contribute to the development of a scientific publication culture among novice researchers.

3. Tshwane University of Technology

Research capacity development is central to the research and innovation strategy of the university. There are many reports on the factors that promote capacity development as well as the challenges associated with this process (e.g. Lombard, 2006; KPFE, 2000; RAWOO, 1995). Horton (2002) provides an appropriate summary of these factors:

- An environment that is conducive to capacity development;
- Top managers who provide leadership;

- A critical mass of involved and committed staff members;
- Availability or development of appropriate institutional innovations;
- Adequate resources for developing capacities and implementing initiatives; and
- Adequate management of the capacity development process.

Each individual operates within the context of an institution, which has inherent factors that impact on research productivity. Institutions that are developing a research culture should strive to ensure that they put in place systems and processes that are enabling and conducive to research. According to Bland and Ruffin (1992) several studies suggest that these characteristics are the most powerful predictors of research productivity. There are various capabilities and requirements that are of importance to individual researchers, for example the capacity to formulate a research problem and independently carry out the entire research cycle, appropriate qualifications, motivation and dedication, opportunities to undertake research, external contacts and networks and access to information and equipment.

It is often assumed that individual capacity development will automatically have the effect of developing and improving the organisation's capacity and performance. However, reports indicate that there are cases where individuals through their own motivation and drive have developed skills in research. This has not necessarily led to a culture of research becoming institutionalised (Lombard, 2006; Horton, 2002; De Lange *et al*., 1996). Capacity development can take place at various levels and it is therefore believed that a holistic and integrated approach is essential to ensure success.

The Tshwane University of Technology (TUT) has a number of institutional and faculty-based initiatives to develop research capacity. Mentioning them all falls outside the scope of this paper and therefore the focus will be on the Research and Innovation Capacity Development Programme (RICDP).

3.1 Research and Innovation Capacity Development Programme (RICDP)

The aim of the Research and Innovation Capacity Development Programme is to provide a comprehensive range of relevant research and innovation development opportunities so that staff are enabled to develop professionally and personally in accordance with their, and the university's, needs. The objectives of the RICDP are:

- To increase research-based qualifications of academic staff members;
- To facilitate the further development of all current researchers, regardless of their level of development;
- To assist in the development of a new generation of researchers by focusing on staff members in the early stages of their careers; and
- To increase the number of NRF-rated researchers at TUT.

The Directorate of Research and Innovation plays a role in meeting these goals (within the context of the overall integrated staff development strategy) primarily through:

- Coordination and publication of research development opportunities;
- Providing support and advice regarding research development opportunities, activities and needs;
- Promoting and administering the programme; and
- Collaboration with other units within the university to ensure an integrated approach to capacity development.

The approach to the RICDP assumes that there are generic competencies and capabilities which all researchers need to develop and that no matter what the level a researcher might have achieved, there is still an ongoing requirement for professional and career development.

The fundamental starting point is embedded in a Competency Framework, whereby individuals, in discussion and negotiation with their departmental heads, should identify required competencies and required interventions to improve performance in the area of research and innovation through a process of self-assessment. Based on this

assessment, researchers are categorised as researchers in training, early career researchers, active researchers and established researchers for management purposes. Institutional definitions apply to each category.

The RICDP consists primarily of four types of interventions that are currently at different stages of implementation:

- Research competency development;
- Mentorship;
- Networking and exposure; and
- Researchers' forum.

Research competency development

A series of modules are presented. The training and competency development required by each individual depend on their level of development and experience. General courses are offered on scientific research (philosophy, definitions, concepts, ethics, etc.), the research process, proposal writing, electronic databases, quantitative research methodology, qualitative research, supervision of postgraduate students, time management, sources of funding and scientific presentation.

Packages of interventions are developed for specific categories of researchers. For example, the researchers in training (studying towards a postgraduate qualification) will benefit from selected elements of the generic modules, but in addition need modules on research output, scientific writing and financial management. The research active staff will benefit from selected elements of the generic modules in addition to modules on advanced proposal writing, networking and collaboration, grant management, NRF rating, mentorship training, ethics in research and commercialisation.

Based on a needs analysis, the following were also identified as requirements for research-related competency development:

- Supporting staff in technology and knowledge transfer – in particular support is required in the development of consultancy skills and knowledge, understanding of intellectual property and the impact

of its management on the university;
- Supporting staff to establish closer links with industry and to move to a more commercial operating environment – given the move towards more formalised business planning, there is a need to develop all senior to middle managers in "good practice" in development of business plans, risk assessment and commercial awareness;
- Supporting staff in the development of communication skills; and
- Supporting the professional development of those newly appointed staff in management roles within the institution.

Some of these will be incorporated in future training or new modules developed. TUT is running a TUT Management and Leadership Development Programme called "License to Lead". One of the modules in this programme targets heads of academic departments. It is believed that the head of department plays a very important role in supporting research and establishing a research culture in the department.

In addition, workshops on scientific writing were introduced in 2009 to increase the capacity to produce scientific papers and consequently the publication output units received from the Department of Education.

Mentorship

Various types of mentorship are possible. In cases where an individual is studying for a higher qualification, the supervisor and co-supervisor could play an important role in terms of mentorship. However, it is recognised that mentorship goes beyond the mere supervision of the research. This initiative is in the early stages of implementation and aims to establish faculty mentorship teams consisting of four to five more senior researchers who have been successful in obtaining significant external research funding and have proven research leadership and mentoring ability. It is believed that this system will fast-track the development of novice researchers.

Linked to mentorship but also to research capacity development in the broader sense, a strategy to appoint what is called Research and Innovation Professors was adopted by TUT in 1999. A total of 13 of these positions were filled and they were linked to institutional niche areas. In the majority of cases they made a huge impact in focusing research activities in a particular niche area and were the catalyst for capacity development and increased productivity.

Networking and exposure

This deals with the planning for career development – for example, in terms of study visits, postdoctoral studies, sabbaticals, research-related training, establishing networks, etc. This aspect is highly dependent on the individual researcher's needs, level of development and field of research.

Researchers' forum

The primary aim is to have a community of practice. Researchers need to get together as researchers to discuss research-related issues – be they of a generic nature and/or more specific. In many instances these forums are arranged within the context of a niche area. A forum for postgraduate students that will be facilitated in collaboration with the institutional postgraduate forum as well as a forum for postdoctoral fellows are in the process of being established. It is therefore envisaged that a number of these "communities of practice" will be active throughout the institution.

3.2 Reflection

The initiatives to support the development of individual researchers did in the case of TUT result in institutional progress. It must be emphasised that the institutional research budget made generous provision for individual capacity development and the development of niche areas. A funding formula was developed through which the institutional niche areas receive base line funding as well as performance-based funding.

A number of selected indicators (there are other relevant indicators) were used to summarise the institutional progress that is reflected by the development of individual staff members (Table 2). Although it is commonly accepted that outcomes for research capacity development include the traditional research output measures of publications, conference presentations, qualifications obtained and successful grant applications (Cooke, 2002), it should be remembered that research capacity development is a long-term effort and for this reason adequate time must be allowed before the outcomes and impact of research capacity development interventions are measured. Returns on the investments are often indirect and are only visible several years after the research capacity has been established.

Table 2: TUT's progress over the period 2004–2008

Indicator	Percentage increase
Qualifications awarded to masters students	36%
Qualifications awarded to doctoral students	78%
Permanent instructional/research professionals with a master's degree as highest qualifications	18%
Permanent instructional/research professionals with a doctoral degree as highest qualifications	8%
NRF-rated researchers	87%
Percentage of permanent instructional/research professionals with a NRF rating	89%
Accredited publication output	82%
Publication output per permanent instructional/ research professional	75%
Funding from agencies	132%

It is evident that the combination of capacity development interventions did result in the improvement of an institutional culture for research and increased productivity.

Observations

Based on these case studies, the following observations can be made:

- Researchers at all levels need support for the research enterprise. The attention they receive contributes positively to their sense of self-worth, and the appreciation of the significance of their contribution to scholarship and knowledge generation.
- Support for research supervision acts as a quality management measure that standardises the criteria used for measuring performance and promotes fairness in the assessment and evaluation of postgraduate studies.
- Mentoring sustains and perpetuates scholarship. In addition, it strengthens the bonds between academics building an academic culture that values research and recreates and reproduces itself beyond time and space boundaries.
- Technology transfer, a relative newcomer to the academic and scholarly enterprise, is ascending in UoTs. However, there is a definite need for guidance because of external developments such as the establishment of the Technology and Innovation Agency (TIA) and the promulgation of the Intellectual Property Rights Act, and other related frameworks.
- A stimulated academic environment contributes to a sustained research culture. One spin-off is a critical mass participating in research activities such as publication writing.
- In-house publication opportunities can overcome the psychological hurdle to publish research. This stumbling block is similar to the proverbial "writers' block". Dealing with this matter also contributes towards the drive for academic staff development.
- The roll-out of a publication model also contributed towards a better understanding of scientific writing. This in itself led to some publications in accredited journals which, in return, stimulated the debate on research publications.
- Research capacity development is an ongoing process within an ever-changing environment that involves individual researchers, their institutional environment and the broader enabling environment.

- Research capacity development takes place at different levels and each level has an effect on other levels.
- For the development of individuals and groups, factors such as personal motivation, basic research skills, advice and mentorship, networks, peer support, sufficient time and a supportive environment are critical.
- The university should place priority on research productivity to the same extent as it does on its other missions.
- Linkages, partnerships and collaborations enhance research capacity development.
- The NRF (and its predecessors) were an important ally and partner in the development of research at the UoTs, especially in view of the skewed nature of the funding formula for research which largely excluded the then technikons.

Conclusion

These case studies provide valuable insights into the way in which research capacity-building initiatives are rolled-out. One can also learn from these case studies that core to all research capacity-building initiatives is human resources development supported by an enabling and sustainable research environment.

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Working for a degree: work-integrated learning in the higher education qualifications framework

Associate Prof. Penelope Engel-Hills, Dr James Garraway, Associate Prof. Cecilia Jacobs, Associate Prof. Terry Volbrecht and Prof. Christine Winberg

Abstract

This paper responds to the guidelines on work-integrated learning (WIL) in the recently promulgated Higher Education Qualifications Framework (HEQF) (Department of Education, 2007). The paper elaborates on some of the definitional issues regarding WIL in an international context, characterised by growing concerns with the employability of graduates. Terms familiar in the South African context, such as "cooperative education" and "experiential learning", are briefly discussed in relation to other commonly used terms in the literature, such as "workplace learning", "work-based learning" and WIL as defined by the Work-Integrated Learning Research Unit (WILRU) at the Cape Peninsula University of Technology (CPUT). A typology of four different approaches to WIL is developed: work-directed theoretical learning (WDTL), problem-based learning (PBL), project-based learning (PJBL) and workplace learning (WPL).

The key theoretical constructs underpinning the notion of WIL are discussed; these include constructs that seek to theorise the transfer and recontextualisation of knowledge as it moves in complex ways between university and workplace settings. Different ways of integrating the different forms of knowledge are then discussed and theorised. Finally, the planning and implementing of WIL is addressed. Each of the four types is discussed in terms of curriculum, pedagogy, student learning, assessment and workplace involvement considerations. Illustrative case studies describe instances of planning and implementation, the resources involved, and the HEQF level of the particular case.

Background and context

This paper is written in the context of considerable debate around the recently promulgated Higher Education Qualifications Framework (HEQF) (Department of Education, 2007). More specifically, the paper responds to the guidelines on work-integrated learning (WIL) for qualifications registered on the HEQF, which are as follows:

> "*Some qualifications will be designed to incorporate periods of required work that integrate with classroom study. Where work-integrated learning (WIL) is a structured part of a qualification, the volume of learning allocated to WIL should be appropriate to the purpose of the qualification and to the cognitive demands of the learning outcome and assessment criteria contained in the appropriate level descriptors.*
>
> *It is the responsibility of institutions, which offer programmes requiring WIL credits, to place students into WIL programmes. Such programmes must be appropriately structured, properly supervised and assessed.*" (Department of Education, 2007: 9)

These guidelines conflate WIL and workplace learning; they do not address the range of WIL that is practised in both traditional universities and universities of technology (UoTs), nor do they address recognition of prior learning or life-long learning. The guidelines are too brief to be helpful in the development of career-focused curricula (and associated supervisory, supportive and assessment methods). In an attempt to address this gap, this paper draws on international and local research and practice, for the purpose of providing additional guidelines for the development of career-focused higher education programmes.

Defining work-integrated learning

Within the higher education sector internationally (e.g. Saunders and Machell, 2000), as well as in South Africa (e.g. Department of Education, 1997; 2002a, 2002b; South African Technology Network, 2008), there have been calls for increased graduate employability. The UK-based Dearing Report (1997), for example, recommends that all students obtain work experience associated with their qualifications. Innovative curricular, pedagogical and assessment forms have been developed in response to these concerns.

In the South African UoT context, the term "cooperative education" has been used to describe the placement of students in appropriate workplaces for the purpose of gaining work experience, with the cooperation of potential employers. The term "experiential learning" has a greater variety of meaning in the international literature (e.g. Boud and Garrick, 1999; Billett, 2001; Illeris, 2007; Zemelman, Daniels and Hyde, 1998). The term "work-based learning" (WBL) has been preferred to describe "learning for, at, or through work" (Brennan and Little, 1996). WBL involves the acquisition of work-related knowledge and skills both in the university and in the workplace, with the involvement of employers (Boud and Solomon, 2001).

The Work-integrated Learning Research Unit, based at the Cape Peninsula University of Technology, has preferred to use the term "work-integrated learning" (WIL) to describe an approach to career-focussed education that has much in common with WBL in that it includes theoretical forms of learning that are appropriate for technical/professional qualifications, problem-based learning (PBL), project-based learning (PJBL) and WPL. What distinguishes WIL from WBL is the emphasis on the integrative aspects of such learning. WIL could thus be described as an educational approach that *aligns* academic and workplace practices for the mutual benefit of students and workplaces. WIL is based on the principle that learning should be demonstrated to be appropriate for a qualification and should be assessed wherever it takes place or is provided.

It is worth emphasising that the alignment between work and education implied in WIL is not restricted to WPL (it seems as if the HEQF has conflated WIL with WPL). There are a wide range of WIL practices along a continuum from more theoretical to more practical forms. WIL includes, but is not limited to, learning from experience. When WIL includes experiential learning, the intention is to encourage students to reflect on their experiences and develop and refine their own conceptual models. These capabilities are just as necessary for career-focused education as they are for general education.

Theorising work-integrated learning

Cognitive knowledge learned at the university does not transfer itself into practice in the workplace in a straightforward or uncomplicated way. One reason for this is the fundamental difference in the way knowledge is organised in university courses, which is largely in the form of separate academic subjects, in contrast to the more interdisciplinary way that knowledge is drawn on in the practice:

> "*The problems which people construct from their experiences do not easily map on to existing scientific and pedagogical organisations of knowledge. What is needed in solving a technological problem may have to be drawn from diverse areas of academic science at different levels of abstraction then synthesised into an effective instrumentality for the task at hand…Solving technological problems means building back into the situation all the complexities of real life, reversing the process of reductionism by recontextualising knowledge.*"
> (Layton *et al*., 1993:58-59)

Certain practical interventions learnt at the university do transfer well to the workplace, but are necessarily limited to reproduction in the workplace. Where the workplace context is more complex, transfer becomes more difficult. Eraut (2004) outlines a model for the transfer and integration of academic knowledge into work situations. The process of transfer is essentially one of "liberating" academic knowledge from the confines of the university. The stages involve:

- The initial extraction of academic elements;
- Understanding the new context;
- Adapting knowledge for the new context; and
- Integration for action.

This is a complex process that is not usually accommodated in traditional university studies.

Difficulties arise when workplace knowledge is brought into the university. The nature and structure of university subjects are such that the work knowledge has to become disaggregated into discrete subject elements. Academic staff who have attempted to bring real projects into the classroom, for example, in PBL in engineering and medicine, are familiar with these difficulties. Questions arise such as: "Is there sufficient mathematics involved?" or "How can I, as a biochemist, teach a student about physiology?" Subject domains remain the dominant organisational principle for knowledge at the

university, despite attempts to shift to more integrative approaches through outcomes-based education. Subject knowledge teaching remains the best way to induct students into conceptual understanding of, for example, physiology or mechanics.

The key to understanding knowledge transfer between higher education and work is rooted in their different contexts and hence the idea of "recontextualisation" (Bernstein, 2000), which occurs when knowledge learnt in one site is transferred to another. Knowledge from outside the university can be disaggregated and selectively recombined according to disciplinary requirements, although the new product is frequently decidedly different from its source.

According to Barnett (2006), the recontextualisation route for vocational subjects – such as those in law, medicine, engineering, education, commerce, social work, and so on – involves the selection of elements in the field, not through a focus on teaching and learning, but through the lens of application-orientated subject knowledge required by the professions. Once suitable subject matter has been identified, the second aspect of recontextualisation involves re-packaging of the curriculum as teaching and learning units. The way in which the academic discipline "physics" is re-packaged into the engineering subject "applied mechanics" or into the health sciences as "medical physics" could be said to follow this process. There is an additional level of academic recontextualisation in which typical work practices are made more academic in nature. An obvious example in engineering is the recontextualisation of collaborative workplace activities, often across hierarchies and job types, into student group projects: the focus hereby changing from work to education.

What has been argued thus far is that academic ways of doing are substantially changed in transfer to work and bear little resemblance to their origins. The same holds for work knowledge inserted into the academic curriculum that, through processes of recontextualisation, may no longer be recognisable as work. This difference between work and academic vocational knowledge is a stumbling block to implementing WIL (except at the most basic level of replication of procedures).

Activity theorists (e.g. Engestrom, 2001) provide us with an approach to understanding how work and academic knowledge may be integrated as a platform for WIL. The difference between knowledge from different contexts is not an impediment to development, but a resource that can enhance development. "Difference" can serve to accentuate the essence of work and study, and provide a platform from which each may better understand and critique the other. From this the possibility of mutual rather than one-sided recontextualisation develops, resulting in knowledge that is a novel combination of previously contextually bound knowledge.

Planning and implementing work-integrated learning

With the understanding that WIL involves complex curricular, pedagogical and assessment considerations that differ from those of general programmes, WIL can be said to include four main curricular types, with possibilities for many hybrid combinations. The four basic types are described below.

Work-directed theoretical learning

All career-focused programmes will include theoretical subjects or components. An example would be a subject called "Mathematical Foundations of Engineering" in contrast to the more traditional "Mathematics I". The former would attempt to bring theory and practice together in meaningful ways. The theoretical components of WIL curricula need to take into account the dual nature of career-focused education, that is, the curriculum needs to meet the demands of both the discipline and professional practice (Barnett, 2006). In work-integrated theoretical learning, the acquisition of discipline-based content knowledge should include active forms of learning – such as group learning, demonstrations, tutorials, practicals and experiential (in the sense of "hands-on") learning opportunities (Brockbank and McGill, 1998). Formal lectures (that could include guest lectures by workplace representatives) are not excluded.

Group and autonomous learning should be promoted (e.g. through research projects, reading assignments, seminars) in order to align theory with workplace demands (Bennett, Dunne and Carre, 2000). Expectations similar to those of related workplaces (e.g. attendance, deadlines) should be placed on students (Saunders and Machell, 2000). Assessment should simulate workplace models where these are appropriate, for example, technical reports might replace academic essays where appropriate (Dias *et al*., 1995; Winberg, 2007b). External workplace-based examiners are likely to be involved in curriculum planning and assessment; and their selection, appointment, role, training and guidance should be appropriate (Gibbs, 1995).

Case study 1: Work-directed theoretical learning in architecture

Description: Teaching and learning in a history of architecture programme was studied, with a view to finding ways of aligning the theoretical historical component with professional practice. Architecture, like most of the professions, requires not only a vertical knowledge base (in structural physics, aesthetics, and design), but also the ability to draw on these disciplinary reservoirs in building new knowledge to address particular structural and design problems in particular contexts. The education of architects should expand on students' vertical knowledge bases, but should also create opportunities to the enable the "circulation" of vertical knowledge and horizontal knowledge to better prepare students for the professional repertoire in which there will be a constant need for such circulation.

Resources: Professional architects spend much time visiting sites, assessing the feasibility of a project, inspecting building work, or managing the construction process. They will also spend time researching old records and drawings, testing new ideas and construction techniques. It was recommended that some of these be simulated in this history curriculum. One way to achieve this might consist not only of learning text-based knowledge about buildings (whether historical or contemporary), but learning to draw on reservoirs of disciplinary knowledge (structural, aesthetic and design) in the application of these. Architects in practice work closely with other members of the construction industry, including engineers, builders, surveyors, heritage (and other) consultants, and local authorities; this too might be an area for productive WIL. It was recommended that architectural students engaging with structural engineering students around design problems might be another way of accomplishing the circulation of vertical and horizontal knowledge.

HEQF (equivalent): Level 5 History of Architecture course, part of a Level 7 qualification.

(Source: Winberg, 2006b)

Problem-based learning

Problem-based learning (PBL) is a term used within higher education for a range of pedagogic approaches that encourage students to learn through the structured exploration of a research or practice-based problem (Savin-Baden and Major, 2004). PBL began in the health sciences, but has since been used in a variety of disciplines and teaching situations, whether within one course unit or to deliver a whole degree curriculum – with undergraduates and postgraduates (Boud and Feletti, 1997; South African Association of Health Educationalists, 2003). An inter-disciplinary team designs carefully structured and sequenced "problems" that direct the students' learning towards the curriculum outcomes. The lecturer ensures that students have access to a variety of resources, while also guiding and advising students. Facilitators are not necessarily experts, but are skilled in productive group work.

As with problems in the real world, PBL challenges should be structured like real-world problems, with the initial presenting situation stimulating learners to generate hypotheses about their cause and possible solution (Heywood, 2006). Problems should encourage students to study documents in order to obtain information and learning should be integrated from a wide range of disciplines or subjects; PBL is more effective within a single discipline or subject (Barron *et al.*, 1998). Information should be integrated from all the disciplines that are core to the educational programme and relevant to the problems presented. The knowledge and skills gained from work experience should not be gained in a passive way. This means that generic outcomes (in the South African context critical cross field outcomes) will have an enhanced role in the learning outcomes of WBL programmes (Brennan and Little, 1996). Such outcomes can be developed at different levels and can be tailored to particular areas of work. It should be noted that PBL is not appropriate as a method for teaching certain basic skills such as reading or computation; however, it does provide an environment for the application of those skills (Boud and Feletti, 1997).

Case study 2: a problem-based curriculum in radiography

Description: Rapid technological, social and contextual changes have required educators to reconceptualise the education and training of radiographers. The training of radiographers is based on the disciplines of physics, chemistry, radiation physics, anatomy, physiology, pathology and psychology and is located within the applied discipline or specialisation of radiation medicine. Typically the student would learn these discrete disciplines in "compartments" or "silos", and then be expected to "self-integrate" the foundational disciplines of radiography during work placement in a clinical facility. Traditional radiography curricula are therefore not closely aligned with the needs and contexts of the changing clinical environment and the previous narrow vocational training of radiographers does not meet the educational needs of radiographers in Africa. Boyer's (1990) integrative idea is aligned with an emerging vision of radiography as a professional community of technological innovators, academic and clinical educators, practitioners, and students who must have a patient-centred approach to their work. This is achieved through a multidisciplinary team that includes a wide range of health care professionals who collaboratively have the best interests of patients at the centre of their practice. The transmission of narrow discipline-based knowledge to students is an outmoded conception of academic work, for "knowledge is not developed in such a linear manner" (Boyer, 1990). A curriculum that encouraged each academic to plan learning activities for problem solving and skills development, including small group work with focussed problem solving, and where the academics/facilitator remained in close contact with the students, thereby enhancing the student to academic relationship and allowing the academic the opportunity to assess student learning properly (University of Vermont, 2003) was considered appropriate. Hence the new university-based radiography curriculum requires educators to be both disciplinary and integrative experts who interpret and facilitate in the learning process. In this integrated curriculum teaching, learning, assessment, research, and service all influence each other in a learning environment that is planned to benefit students' learning for professional practice.

Resources: A national consultative process was used to develop qualification outcomes. Curriculum development teams,

comprising academic radiography staff and clinical educators, were created to translate national outcomes into a local curriculum.

HEQF: (equivalent) levels: Courses from levels 5–7 in a Level 7 qualification.

(Source: Engel-Hills, 2005)

PBL pedagogy aims for an active form of learning: carefully sequenced problems direct students in an active learning cycle. Interdisciplinary teams design and provide the problem simulations that challenge the students to achieve curricular outcomes. The activities carried out in PBL should be valued by both academics and relevant workplaces. In PBL, students' work should be well-aligned with the problem-solving activities of experts and professionals. Facilitators guide students in their work with the problem as they develop problem-solving skills, identify what they need to learn and develop self-directed learning skills. Allowing the problem to be the organising focus for student learning helps ensure that the application of information from various relevant fields enhances meaning-making. Collaboration (with peers, tutors and facilitators) is essential in PBL, and tends to occur naturally. Before completing their work on a problem, the students and facilitator should reflect on what has been learned and determine if there are concepts missing in the students' understanding, and whether additional skills are required. This important step helps convert procedural knowledge gained through problem solving into declarative knowledge for use and recall with other problems in the future (Moon, 1999a; 1999b). The assessment of students must be aligned with the goals of PBL. The ability to monitor performance accurately is essential in developing life-long, self-directed study skills, as is the ability to provide accurate feedback (Longworth and Davies, 1996).

PBL is considered by some as ineffective when it is episodic, added on to, or mixed in with more traditional, didactic, teacher-directed, passive, memorisation- and lecture-based educational methods (Heywood, 2006). However, modifications of PBL have been successfully incorporated into other types of WIL curricula. Problem-based learning requires that students are active learners, responsible for their own learning, and have adequate time for self-directed learning.

Project-based learning

Project-based learning (PJBL) brings together intellectual inquiry, real-world problems, and student engagement in relevant and meaningful work (Barron *et al*., 1998; Blumenfeld *et al*., 1991). Well-crafted projects provide a meaningful and authentic context for learning and immerse students in complex, real-world problems that do not have predetermined solutions (Ayas and Neniuk, 2001). Good practice in PJBL requires students to develop and demonstrate essential skills and knowledge and to draw on multiple disciplines to solve problems and deepen their conceptual understanding. PJBL can result in useful products or services that also demonstrate what students have learned. Service learning (SL) is a form of PJBL that connects students with communities, service partners, and academic experts.

PJBL is an instructional model that supports authentic inquiry and autonomous learning for students (Ayas and Neniuk, 2001). PJBL involves the acquisition of an extensive, integrated knowledge base that is readily recalled and applied to the analysis and solution of problems (Hudson *et al*., 1997). In PBL, problems are usually not simulated, but involve learning and practice in a work context, as in service learning or in a university-industry collaborative research project. PJBL engages students in complex, work-related issues, through which they develop and apply skills and knowledge (Turner, Keegan and Crawford, 2000). Accomplishing these goals requires time for both teachers and students to master the strategies necessary for successful PJBL. Because project work involves many different types of projects within the framework of a single subject, it can be

demanding on staff resources. Projects involve students in regular exhibitions and assessments of their work in the light of personal, academic and workplace standards of performance. Clarity with regard to the assessment process in project work is probably more important than with traditional programmes because of the demands it makes on academic staff.

When projects are done in collaboration with workplaces, there should be both formal and informal liaison mechanisms with workplaces for the purposes of curriculum development or research (depending on the level of the programme), project management (such as keeping track of student attendance in an SL project), and provision of feedback on students and the programme. The university and students need to be sensitive to employers' needs generally, specifically where students may be involved in projects that require confidentiality.

Not all projects lend themselves to "coverage" of all the outcomes in a curriculum. There are two important issues to be addressed: firstly, the level of student involvement in a project, and secondly, whether the students are prepared (both socially and academically) for the level of the work (Hager and Beckett, 1995). Student autonomy is one of the hallmarks of PJBL. In undergraduate PJBL it is prudent to introduce student autonomy in stages, depending upon students' levels and experience. Before planning the project, it would be necessary to decide how much students should be involved in its design and how much autonomy they will have in carrying out project activities.

Case study 3: Project-based learning in mechanical engineering

Description: Students in the Mechanical Engineering Department at a UoT study the subjects and disciplines traditionally associated with Mechanical Engineering: mathematics, physics, fluid dynamics materials, manufacturing, technical drawing, and communication. In addition, students, at every level, also participate in an integrated task (IT), which is intended to bring the separate subject areas into a meaningful relationship. The IT has a planning phase, a design phase, a manufacturing phase, and a reporting phase, all of which are assessed. Students are given a "project brief", put into project teams and, with limited support and guidance from a mentor, are expected to accomplish the task. The students plan the project, set goals, outputs and deadlines, order materials, book time in the workshop, and generally take charge of their own projects. The academic staff meet to decide on a suitable project and to develop a project brief. Ideally, the IT has both relevance to the real world of mechanical engineering and includes sufficient coverage of the academic subjects – a task that is difficult to achieve. The staff collectively develop criteria, not only for their subject areas within the project, but for the IT as a whole.

Resources: It was recommended that there be additional formative assessment in the form of debriefing and reflection, and that the report writing criteria are more closely aligned to professional standard technical reports. Greater workplace involvement in the planning and assessment of ITs was also recommended.

HEQF (equivalent): Level 7 courses in a level 7/8 qualification.

(Source: Breslow *et al*., 2005)

Workplace learning

WPL curricula tend to be based on Kolb's (1984) learning cycle, or versions thereof. The learning cycle proposes an iterative series of processes which underlies learning. Learning becomes less efficient where one or more of the learning cycle stages is missing, or where a student lacks the skills or opportunity to deal with one of them (Moon 2004).

The inclusion of PBL and PJBL prior to work placement are helpful in preparing students for successful WPL (Harvey, Geall and Moon, 1998). When academic staff is unfamiliar with the demands of WPL and the assessment of learning through practice, staff development or industry collaboration would be required.

Many professional programmes include a practicum, which can vary from a few weeks to a few years of practical experience at a site of practice. This model can be strongly or weakly integrated into the formal learning programme, depending on how it is supported, supervised, and assessed. In such programmes, the workplace is present, both as a learning resource and as a benchmark of practice. Much of the training of health professionals takes place at the site of practice, traditionally a large general state hospital. In this model, a satellite university campus is established in a host institution and a transdisciplinary construct known as a "teaching hospital" is created. This brings elements of the learning environment (lecture halls, tutorial rooms, libraries, demonstrations, etc.) into the daily activities and practices of the hospital as a workplace (Winberg, 2006a). Students, as early as the first year, are brought into the workplace, and are simultaneously acculturated into academic and workplace knowledge systems.

Many other career-focused higher education programmes include some form of WPL, in the form of industrial placements, job-shadowing, professional practice to support a professional qualification, and employer- or employment-based schemes, such as learnerships. In order to be accredited within a qualification, such learning would need to be measured and assessed against specified learning outcomes and assessment criteria. Examples of such learning already taking place in traditional university and UoT programmes include traditional "sandwich" courses, specific skills training in particular professions, and the theoretical application of practical experience in part-time professional courses.

Difficulties arise in contexts where the site of practice does not have appropriate structures and systems to support student learning.

The lack of structural support for learning and assessment has caused many well-intentioned WPL interventions to fail. In traditional universities, the engineering disciplines have tended to separate theory and practice. The university offers theoretical engineering and an academic qualification, while the engineering councils accredit engineers as professionals. There are several reasons for this. One reason is that, unlike hospitals and schools, there are no specifically teaching-oriented engineering workplaces linked to universities. In commercial and industrial contexts there are few structures or resources that support student learning, or supervise and assess pre-entry practitioners. Where such structures are lacking, WPL is not always appropriate in an undergraduate programme because learning conditions are too varied (i.e. dependent on the individual workplaces), resulting in potentially good learning in some contexts and very poor learning in others. In the case of engineering, PBL and PJBL have generally been more effective than WPL (Savin-Badin and Major, 2004). Another reason why WPL has not always served the purpose that it was originally designed to meet, has to do with the changing nature of workplaces. Many employers require entry-level employees with high-level technical skills, and this makes a first- or second-year student "apprentice" not particularly useful in a modern technology-based workplace, nor does it provide the student with appropriate learning experiences. The UoTs are thus seeing a decline in the cooperative education system for the same reasons that the apprentice system has declined in the rest of the world (Young, 1998). An additional reason has to do with differences between theoretical academic knowledge and contextualised workplace knowledge – and the difficulties of creating meaningful articulation between them – particularly when the difference between the knowledge forms and structures are poorly understood by both educators and workplaces.

It needs to be acknowledged that effective WPL is unlikely to happen without strong theoretical learning. Students will need a solid grounding in the disciplines associated with their programmes of study in order to gain full competence in their professions. If this is not the case, polarity is likely to occur and an "antidisciplinary" attitude taken in which vital discipline-based concepts are ignored or trivialised, rather than enlarged through linkages among disciplines and across contexts (Winberg, 2006a). Students should also understand how the knowledge production systems of the disciplines are relevant to extra-academic contexts, if they are to prepare themselves adequately for South Africa's diverse social and economic needs.

Case study 4: Experiential learning in chemistry

Description: Chemistry students at a university of technology spend a year in industry. Students working at the council are firstly rotated through the various laboratories in the water and sanitation department and are required to successfully complete a set of tasks against outcomes. The tasks are supervised by experienced staff in each laboratory. As one supervisor stated, "We have the most up-to-date equipment which students learn to use". Top-class scientists are available and everybody is willing to help the students with any problems they may have, so much so that when the students are not around they begin to ask where they are. In the second half of their industry experience they work on a small-scale research project. These are projects which the regular staff would like to do but do not get around to doing. They are something useful for the industry in that they fill a gap. At the council, one student was investigating the optimal pH for the precipitation of zinc, cadmium and nickel, which are common in industrial effluent and must be removed before the water is recycled.

Resources: Support is provided by practicing chemists with only limited support from the university. The lecturers mostly help with the conceptualisation of the project and respond to email enquiries from students.

HEQF (equivalent): Level 7 in a level 7/8 qualification.

(Source: Garraway and Volbrecht, 2007)

Appropriate assessment of experiential learning should be part of a coherent assessment strategy. Experiential assessment might include learning diaries, portfolios, student progress files, and other means by which learning through and at work can be documented – together with the relevant marking criteria. Academics and workplace representatives need to ensure that the work experience provides appropriate learning opportunities. Where WBL is planned, this will necessitate strategies and procedures for finding suitable employers or partners and some form of risk analysis in workplaces. In establishing "trans-disciplinary" partnerships, the problem is usually constructed as for the university, its structures and traditions (Boud and Tennant, 2006), but there are equal challenges for workplaces and their practices. These involve workplaces become more educational, in the sense of providing opportunities for learning, support, guidance, and reflection – all of which require an understanding of the constraints of contextual embedding and local practice on student development (Winberg, 2007b).

Students, particularly if they are full-time students at the university, need to be adequately prepared in order to learn in a work environment. Students need to understand the expectations on them as employees (even if unpaid). In some professional areas of work, employers require the university to certify students' fitness to practise (Harvey and Knight, 2003). These expectations, as well as practical arrangements made, should be provided to students in the form of guidance documentation. Student induction in the placement environment has been found to be helpful (Gosling and Moon, 2001). Information should be provided to students regarding how to record their progress and achievements and fulfil the assessment of learning outcomes, particularly in those activities with which they might be less familiar, such as the production of portfolios or reflective journals. Students will need guidance on what to do if there are work problems which might affect their ability to achieve the learning outcomes. Figure 1 on the following page provides an overview of WIL practice.

Figure 1: A WIL typology

Type of learning	WDTL	PBL	PjBL	WPL
Terms and practices associated with the learning type	Classroom-based instruction, lecture, tutorial peer learning groups	Sequenced real-world problems, integrated learning, discovery learning, self-directed learning, peer learning groups	Industry project, "real-world" learning, guided practice, "capstone" modules	"In-service" work placements, cooperative education, practicum work-based learning, "sandwich" courses, apprenticeships, internships, traineeships
Examples of work-integrated learning activities	Career-focused courses and curricula (e.g. maths for engineering, communication for business), guest lectures (e.g. from industry), authentic examples, workplace assessors (e.g. student presentations)	Work-simulated problem/ task & texts, group work, facilitated learning process	Study visit, site visit, job shadowing, authentic tasks & texts, fieldwork, interviews, team work, service learning, integrated trans- or inter-disciplinary projects	Learning contracts, log books, learning logs, journals, mentoring, specific training, learning portfolios
Sites of learning	Lecture theatre, classroom, laboratory, studio, websites	Classroom, laboratory, group sessions, library, electronic media	Multiple sites: classroom & workplace, laboratory & workplace, etc	Workplace & classroom (for preparation & reflection)

There are a number of practical and logistical considerations that need to be addressed when students learn off campus. There are regulatory issues relating to placements, such as provision for failure if the experience cannot be replicated to enable re-submission. There may be a need for contingency planning, as well as mechanisms for dealing with problems or complaints. Procedures for supporting WIL should include changes in staff contact time, the nature of that contact and the administration demands of record keeping for students on placements. This may involve the development of a contract to govern that relationship, including legal responsibilities and the boundaries of any assessment role. The workplace responsibilities of students in placements should be clear and agreed upon. The potential for the same employer to be approached from a number of sources, if the development of student placement grows significantly, should be considered. The university should make available different forms of support to deal with issues around the placement. All groups (students, workplaces, and academic staff) should be provided with practical information: health and safety regulations, insurance matters, legal or ethical considerations, and so on.

Conclusion

Work-integrated learning is a form of learning which has value in particular sets of circumstances as outlined in this paper. WIL should be accommodated by the standard procedures and structures of the university as far as possible, acknowledging that WIL makes additional demands on universities, staff, students and workplaces as discussed above. This position paper serves as a pointer to why and where those variations occur.

Credit-bearing WIL programmes and modules should comply with the standard quality assurance processes within the university. The quality office should be aware of the specific demands of WIL. The HEQC needs to provide much more detailed sets of guidelines

for WIL. Among the challenges that WIL poses, is an extended role for higher education. South African university educators, in conversation with international peers, will need to develop curricular and quality management systems that build on current strengths and address areas of weakness.

Both the Department of Higher Education and Training and the CHE have made it clear that the implementation of the new HEQF will be a slow and gradual process. This process provides opportunities for growing the knowledge-base of WIL in higher education. We strongly recommend that the DHET provide financial and other forms of support to UoTs for the processes of recurriculation and the research that should inform these. The proposed Teaching Development Grant could be one vehicle for providing the necessary funding to ensure that WIL curricula and the related pedagogies are rigorously developed.

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Technology transfer at universities of technology – operating as "new generation universities"

Prof. Deon de Beer

Abstract

International literature suggests many advantages for the collaboration between industry and universities, and with many successful management models. While some of these models and success stories are found among South African higher education institutions (HEIs), little is known about the wealth of knowledge resources within the upcoming new generation of entrepreneurially-oriented South African universities – the universities of technology (UoTs).

Developed from the old technikons, UoTs are not merely old institutions with new names but are facing the challenge of earning their rightful place in the South African higher education sector, and within its new mandate.

The author uses his experience of two decades in the technikon and UoT environment to benchmark international technology transfer practices as applicable to stimulate innovation and economic development in the South African context. The findings from literature surveys are supported with physical research, development and

technology transfer successes based on leading a multi-disciplinary research niche area within the UoT environment. The paper furthermore places multi-, inter- and transdisciplinary development and knowledge partnerships within the UoT domain.

Introduction

In an address to discuss partnerships in higher education, Moutlana (2009) referred to the mandate of higher education institutions (HEIs), and pointed out, among other things, that HEIs are responsible for the creation of knowledge, and to make this knowledge, underlying expertise and infrastructure available through partnerships with industry and commerce, as well as the community is essential. She concluded that, as part of the university's mandate, over and above teaching and learning, HEIs have a "public life" and need to make a social contribution. Moutlana's words imply that irrespective whether the recipient of the knowledge is industry, commerce or the community, the action can be packaged under the term "technology transfer".

Louw (2008), in a paper on "new generation universities", states that new generation universities "do different things". He concludes that the "different things" span the main focus areas of teaching and learning, research and community service, but under a broader, integrated focus of serving society and, more particularly, their immediate communities.

In his discussion, Louw makes a case that new generation universities would thus offer a far greater set of learning programmes, covering a wider spectrum of qualifications, such as certificates, diplomas and degrees and, in some areas, do so from the initial entry level up to the PhD level.

This approach means that new generation universities offer discipline-based and inter- and multidisciplinary-based as well as

transdisciplinary learning programmes, which sets an MIT[1]-agenda. It means they are positioned to respond easily to changes in the knowledge environment.

He continues to argue that in the field of research, new generation universities are far more centred on problem-solving or user-inspired research, which relates to challenges faced by their constituent communities. The research of new generation universities is usually characterised by knowledge diffusion or technology transfer whereby the knowledge generated by researchers is infused into industry, business, government authorities or civil society (Louw, 2008).

Research, innovation and technology transfer (as value chain to support economic development initiatives)

Neville Comins, founder and first CEO of the Innovation Hub, points out that even though South Africa is a country with a relatively small economy on a world scale, South Africans have achieved significant global recognition for important contributions to technological innovation (Comins, 2005). As such, the South African government is well aware of the need to stimulate entrepreneurship, innovation and growth among knowledge-intensive businesses, and have created a number of agencies to support SMMEs.

Comins furthermore points out that most South African universities have organised activities to support technology transfer, innovation and entrepreneurship. David Phaho, CEO of Tshumisano Trust, highlights such an agency and public partnership, when he discusses the success of Tshumisano to support the South African tooling industry. He points out (Phaho, 2008) that at the stage when South Africa re-entered the global economy after years of political isolation,

1 MIT = multi-, inter- and transdisciplinary programmes or approach.

there was a drive to enhance the competitiveness of its key industries and enterprises. He explains that central to industrial competitiveness, economic growth and employment creation is the growth of small-, micro- and medium-sized enterprises (SMMEs), and continues to explain that the Tshumisano Technology Stations programme has become a key contributor to the process of technology transfer and SMME support (innovation and increased competitiveness). Imitating the very successful Steinbeiss Stiftung in Germany, and initiated through bilateral agreement between the South African and German governments with GTZ as support structure from Germany, the South African government launched the Technology Station Programme (TSP) in 1999 with the sole mandate of improving the competitiveness of existing SMMEs through technology diffusion and intelligence from universities of technology.

This sentiment is echoed by Hattingh, when he points out that the National System of Innovation (NSI) framework resulted from a need to understand the determinants for success in regions and countries (Hattingh, 2003). Hattingh explains that Higher Education Institutions are among the most important actors in a national system of innovation (NSI), and are linked into a web with other structures and organisations, such as government, industry, and fourth pillar organisations. Fourth pillar organisations are innovation-enabling and multiplier organisations such as incubators, innovation support centres, technology transfer centres, and technology demonstrators. The triple Helix model captures the interaction and co-development between government, industry, and higher education institutions. This furthermore implies that partnerships are crucial elements of the technology transfer value chain. In a paper by Bakker *et al.* (Bakker, Oerlemans and Pretorius, 2008), the authors discuss *domestic and international innovation partnerships,* and pose the question whether such partnerships matter for innovation outcomes of South African firms. The paper studies the impact of the diversity of domestic and international innovation partnerships on the innovation outcomes of South African firms, and concludes that having an innovation

partnership is beneficial to innovation outcomes. Technology transfer can of course also be an internal process (transfer of technology within an organisation from one unit or department to another) as pointed out in a paper by Mostert and Buys (2008), which implies that both external and internal partnerships are needed for effective technology transfer. (Internal partnerships also underline the MIT-approach as suggested by Louw, 2008.)

Another very important part of the technology transfer value chain is based on a solid foundation of research. This sentiment is echoed in a paper that discusses the return on investment made in innovation (Heher, 2006). The author points out that the commercial success in universities in the USA and Canada has resulted in many other countries taking steps to emulate this performance. Major technology transfer and commercialisation support programmes have been launched in the UK, Europe, Australia, Japan and many other countries – including South Africa. Unrealistic expectations, however, have been generated by the spectacular successes of relatively few institutions. He continues that it is not always realised that the success from commercialisation is proportional to the magnitude of the investment in *research*, and concludes that without a well funded, high-quality research system, it is not possible for technology transfer to make any significant contribution to economic development. International literature surveys agree with this school of thought. An excellent example is an article by Lee and Win (2004), where they express themselves on university research centres: “University research centers are one of the most attractive external sources of technology for the industry”. The authors conclude that in an industrialised country, a strong linkage exists between university and industry to facilitate the exchange of technology. The authors’ research (through the comparison of several research centres’ activities) indicates that the higher the commitment in motivating industry to participate in technology transfer projects, the more successful the technology transfer practices become. They furthermore show that among different technology transfer mechanisms, a joint R&D project is an efficient way to ensure high commitment of industry and increase the transferability and willingness to industry. They conclude that the role of the government is also critical for a successful relationship between research centres and industry, to assist the research centres and provide the funding and other resources.

Technology transfer at UoTs (the doing of different things)

Louw (2008) concludes that the "different things" that new generation universities should be doing, span the traditional university focus areas,[2] but under a broader, more integrated focus. They should be serving society and, more particularly, their immediate communities. This brings the whole notion of technology transfer to the fore. A HESA report that deals extensively with research and technology transfer in South Africa also underpins the aforementioned ideas (HESA, 2006). The report states that knowledge creation in South African higher education institutions offers many examples of the enormous engagement embedded in our institutions of higher learning today. According to the report, higher education in any country must be viewed as a national resource. It does not exist outside of the developmental environment of society. The report goes on to show that higher education research is central to critical national outcomes. These include the following: poverty eradication; establishing national and regional infrastructure; stimulating innovation and economic growth; enhancing political stability, peace, safety and the security of citizens; and democracy and good governance.

In the section dealing with innovative manufacturing and economic development, the authors refer to some of the research done at UoTs, and start off by stating that it is pleasing to see the contributions of South Africa's newer or previously less-prominent universities to the

2 Teaching and learning, research and community service

functioning of our industries. An NRF-funded research niche area at a UoT is listed in the report as a notable example of a very direct contribution of research to industry. The cited research promotes the practices of "rapid prototyping" (RP) – or what is also called "integrated new product development". Through the use of this approach, many products can be manufactured directly from computer assisted design (CAD) without spending more time or money on tooling development. The approach is characteristically concerned with robotised production, but the value of speed is nowhere more urgently felt that in the support of surgeons eager to save rather than amputate limbs. Promising results have been obtained in the rapid production of titanium models generated as patient-unique implants.

Having intimate knowledge from developing and leading this activity over period of 15 years at the CUT, the author of this paper will reflect on his experience, and use the discussion of successful developments as basis to draw some conclusions on how research at UoTs and the resultant technology transfer can lead to new innovations and support economic development. Of extreme importance is the fact that close interaction with industry will also identify development needs and in turn will impact on curriculum development.

UoT research rapid prototyping (the what and how and its impact on industry)

Rapid prototyping (RP) is the collective name for a set of technologies and processes used to manufacture models directly from a three-dimensional (3D) CAD model by building them as a series of layers. RP has gained diversity, complexity, sophistication and popularity since its introduction in the late 1980s, and thus far has been used to support rapid product development (RPD) – a manufacturing methodology that accelerates the development of new products from the initial design stage to mass production. RPD involves new technologies such as computer aided manufacturing and design technologies (3D CAD/CAM), RP and rapid tooling (RT), combined with new management philosophies, to address the reduction of time to streamline the manufacturing process. RPD techniques not only allow companies to put new products into manufacturing faster, but also concurrently reduce associated development costs. Internationally, companies are finding these techniques to be extremely beneficial and it is therefore adopted at an ever-increasing rate.

Starting from a position that was lagging behind other industrialised countries, South Africa (and higher education institutions wanting to research the emerging field of additive manufacturing) had a challenge to face. Limited numbers of RP machines were introduced into the country and put to work in a wide range of applications by both the CSIR and one private company. However, the development was not undertaken in a haphazard way and co-operation between HE, industry and government was aimed at an efficient use of the country's limited economic resources. In this collaborative way, the CUT became involved with the CSIR through the author's research project. As limited technologies were available in South Africa, it posed both a challenge and an opportunity for the CUT to develop a novel research niche area (RNA), which could lead to an activity in support of industry needs and in response to government priorities (addressing both the then Department of Arts, Culture, Science and Technology's (DACST) White Paper on Science and Technology, as well as the Committee of Technikon Principals' (CTP) research directive for technikons. It also meant that for the CUT it offered an area for research development that would not have to trail behind existing university research areas under development for a number of decades. As this was entirely a new research field, it furthermore implied that any other institution opting to investigate the same research questions, would face the same hurdles to make development progress, leaving the CUT in a leading position as an early starter/adopter of these technologies. It also offered the opportunity for the CUT to accelerate research development and

to become an internationally recognised product development and computer-aided manufacturing research facility in a fairly short time.

Effect on rapid prototyping development through research and government initiatives

Research has been undertaken in South Africa's HE institutions and also at the CSIR (which has a responsibility for developing innovation in a wide range of areas). Most of the research has been applications-based, often in response to specific industrial needs. Typical examples have been reported by Vincent and Taylor (2001), De Beer and Du Preez (2001), and Young (2003). This situation has arisen primarily from the manner in which these technologies have typically been funded, that is, through government support where collaboration with industry has been a central aspect of the grant. A corollary of this has been the high level of industrial participation in many of the research programmes. Sometimes the machines have been funded for a particular application but with a remit to look for wider application and an obligation to transfer into commercial operation. Therefore, the institutions involved have also become technology demonstration centres. As well as developing better ways to produce models and components, the impact of RP upon managerial aspects of the product development process has also been studied, for example, support of concurrent engineering (De Beer, 2002).

RP implementation and research have proceeded with the firm support of central government. One reason for this is that the Manufacturing Report of the 1998 National Research and Technology Foresight Project produced for the Department of Science and Technology (DST, 1998) showed that manufacturers wishing to compete internationally should focus on integrated product development, process and production system design to speed up production time. The report also listed RP and RT among the key technologies that would assist with this aim. This indicates that RP and related technologies have been firmly established within the South

African government's strategy for industrial development.

Government support for RP research has come directly, through funding made available to purchase RP systems, but also through a series of initiatives where RP has been able to play a prominent role.

The Technology and Human Resources for Industry Programme (THRIP) provides funding for collaboration between industry and academia in a pre-set ratio based on the funding provided by the industrial partner. Several research institutions have made very effective use of this for industry-related RP research.

Role of the Centre for Rapid Prototyping and Manufacturing (CRPM) within the South African landscape

Supporting RP-related research at the CUT is the Centre for Rapid Prototyping and Manufacturing. CRPM (established in 1997) is a triple helix success story, combining efforts from government (THRIP, NRF and Tshumisano Technology Station funding), industry, and the CUT, with research that started in 1995, and now offers a complete research and development service to industry. As an early adopter, the CRPM development (although a success story), was not the mere acquisition and implementation of technologies. Initially, the total South African research system of funding through peer evaluation was the biggest hurdle, as very few persons were informed about these technologies, and hence did not understand their application to industry in general – let alone the South African industry, and in particular having the Free State as home-base. Furthermore, international OEM support for single installations was a difficult equation to solve. It soon became evident that isolated installations would not be a sustainable operation for the CUT, which posed a further challenge, namely to fund further acquisition. Strategic support from the CUT and some private partners, however, made the first two acquisitions possible. Initial support from the NRF and later THRIP started to change the landscape and more and more

industries were getting involved – either through single projects, or through involvement in more strategic projects that started to involve the acquisition of new/strategic platforms and developments, which laid the foundation for a series of triple-helix partnerships or private/public partnerships (PPP). CRPM became a prime example of how an HEI, and a UoT specifically, could position itself through direct triple helix models, and a specific process chain started to develop. Initially, there was only a research focus with limited participation. To be sustainable, a "commercial centre" was developed to support both research and industry applications.

In turn, this initiative was recognised by the DST and a pilot Technology Transfer Unit (Technology Station) developed according to the German Steinbeiss model was funded by DST to accelerate the transfer and diffusion of technology to industry. CRPM became a support structure for both research and technology transfer, and further investments through a combination of own funds (surplus funds), institutional funding, industry and government grants started to follow on almost an annual base. In just more than a decade, CRPM became a national research centre, in parallel with being a technology demonstration, transfer and diffusion centre. Lastly, CRPM became an internationally recognised centre of excellence that boasts the following additive manufacturing technology platforms:

- Solidscape 3D Printer (initial machine bought in 1995/6);
- SLA 250 (bought in 1996);
- DTM Sinterstation 2000 (bought in 1998);
- EOS P380 Laser Sintering (LS) (bought in 2003);
- EOS S700 LS (bought in 2004);
- Dimension 3D printer (bought in 2004);
- SLA Viper si2 (bought in 2005);
- EOS M250X Direct Metal Laser Sintering (DMLS) (bought in 2006);
- EOS P385 (bought in 2006);
- EOS M270 Direct Ti Laser Sintering (DTLS) (bought in 2007); and

• SLA 500 (donated by the CSIR in 2007).

In addition to running the technology platform listed above in a research and technology transfer and diffusion mode, the following ancillary support systems and technology platforms have been developed:

• Computer Aided Design (CAD), Computer Aided Engineering (CAE) and Computer Aided Manufacturing (CAM) in parallel with reverse engineering and quality control/inspection software;
• Computer Numerical Control (CNC) machining (conventional and high speed machining);
• Reverse Engineering (RE) through touch probe scanning, laser scanning and 3D photography, together with further developments to transfer Computer Tomography (CT) and Magnetic Resonance Imaging (MRI) scanned data to 2D CAD and solid modelling data as a basis for medical product development;
• Limited production technologies through silicone rubber moulding, spin- and vacuum casting;
• Mould-making and injection moulding technologies; and
• Light manufacturing platforms for larger scale prototyping of industrial machines and processes.

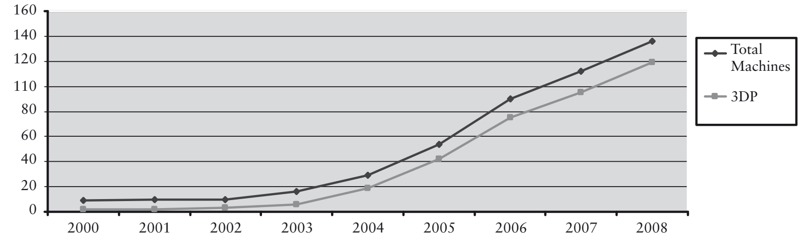
Impact on research, industry support and technology transfer

Following its initial proposals to the NRF during 2005/2006, the proposed manufacturing research initiative has developed into an NRF-funded research niche area (and accredited with "developed" status) focusing on integrated product development (IDP) that now boasts several NRF-rated researchers. Although the research participation can still expand, a sustainable number of individual projects are funded on a multi-year basis. Furthermore, the RNA has managed to expand its funding base to participate in strategic government programmes such as THRIP, the flagship programmes

from the AMTS, the Light Materials Development Initiative (LMDI), the Medical Research Council (MRC) and Tshumisano/ DST funds. Much of these were only possible through showing the interest from industry in the (applied) research results delivered by the RNA. This interest forms a case for ongoing funding from the Tshumisano Technology Stations Programme, as the research results are transferred and diffused to impact on industry's (predominantly SMEs') capabilities to be competitive players in the global product development arena. This is possible both through the involvement ofacademics with industry, as well as industry access to the technology platforms developed.

Figure 1: Summary of RP technology acquisition in South Africa

SAAF Landscape 2008



As can be seen from the graph presented in Figure 1 above, CRPM's technology platform and support is not an "academic monopoly". Through a process of technology transfer (knowledge transfer to industry as well as a process of technology demonstration), the majority (approximately 90%) of these machines (even though in a simpler form) have been adopted and are now owned by private industry.

This also came as a result of CRPM proving the applicability of rapid prototyping and manufacturing platforms to support product development, concurrent engineering approaches, etc., to impact on competitive and innovative product development. Having both the research activity and technology platforms available also implies that CUT students are being trained in extremely scarce and strategic skills, and once again offers the institution a competitive advantage to compete for and participate in strategic government initiatives, such as DST's Internship Programme, and the Fablab initiative. Last-mentioned is aimed at technology transfer and the promotion of science engineering and technology (SET), targeting individuals and learners, rather than industry.

Figure 2 below shows the research foci, while Figure 3 shows the support base for research development, as well as the transfer channels of the research activity, resulting in a two-way flow of support and outputs.

Figure 2: Integrated product development research foci

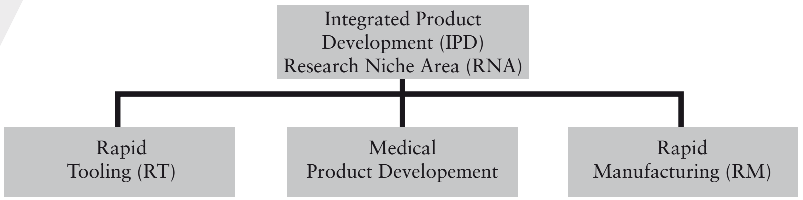
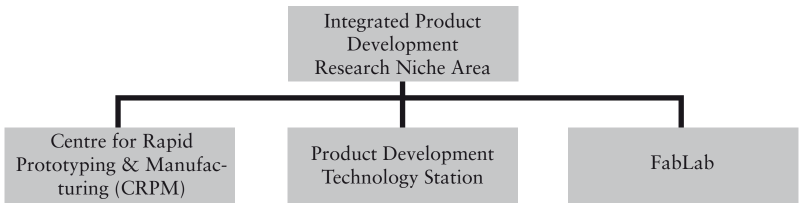


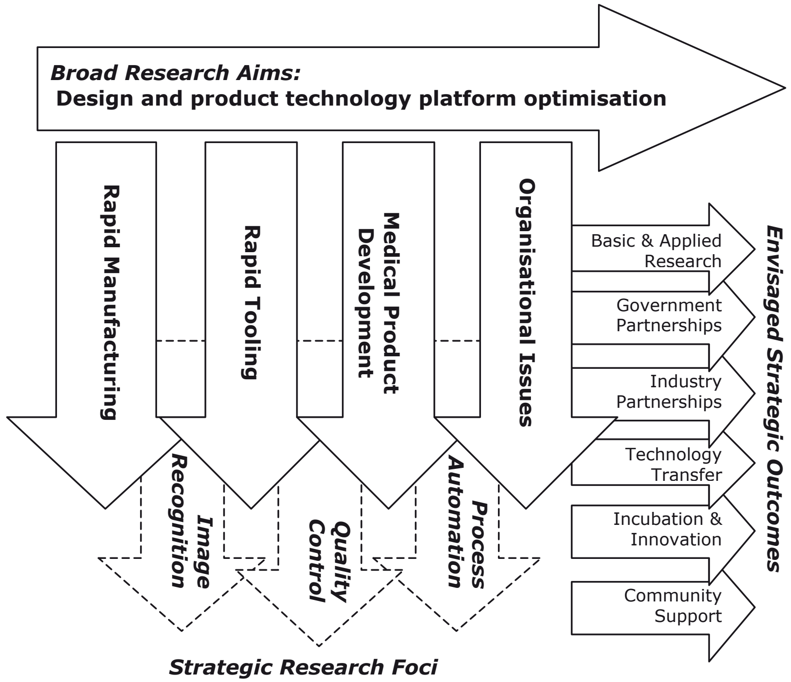
Figure 3: Integrated product development research and technology transfer structures



Further development

CRPM has managed to move from a late adopter (late in terms of international activities) to an internationally recognised unit, with some of the latest equipment available, rarely found in universities internationally. Its unique range of available equipment and funding structure/support base makes it a highly sought-after unit and example of a model for any university, while its achievements are being viewed internationally as nothing short of remarkable. Figure 4 shows the current research foci (as well as supportive research within the Faculty of Engineering, Information and Communication Technologies), together with the expected research outcomes.

Figure 4: Research foci and expected research outcomes



Research, innovation and technology transfer successes (as examples of what can be achieved through UoT developments)

ADEPT airmotive engine development

One of the unique technology platforms available at the CRM is an EOS S 700, a double laser-sintering system for the sintering of sand, which builds cores and moulds for sand casting directly from CAD data, fully automated and without any tooling. Sand parts of any complexity are built layer by layer, with high accuracy, detail resolution and surface quality. The resulting cores or core packages are realised with significant savings in time and costs compared to conventional technologies. Usually they also consist of fewer parts, which are thus assembled faster and more precisely.

Sand sintering with the EOS S 700 enables the production of castings in batch sizes that would be extremely laborious, economically unviable or even impossible to manufacture with conventional techniques. In this way, high-quality castings are produced for engine development, for pumps or hydraulic applications. The castings can be used as fast, cost-effective prototypes or as final products in small series. The technology allows foundries to cater for new trends such as spare parts on demand.

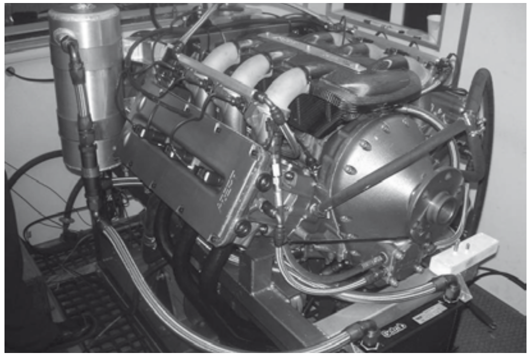
Through support from THRIP, ADEPT Airmotive from Durban and EOS GmbH from Germany partnered with the CUT's IPD to acquire an EOS S 700 to support the development of a home-grown V6 light aircraft engine, and which has been described by Keith Campbell, Senior Contributing Editor to the Engineering News (Nov-Dec 2007) as probably the most advanced piston engine for general aviation (GA) aircraft in the world. The six-cylinder narrow-angle (120º) V6 unit is a compact and an inherently smooth and balanced engine, attributes which are critical for aviation purposes. Being able

to achieve approximately 5 500 rev/min, the engine will deliver more than twice the running speed of existing GA designs. In comparison with existing GA engine designs of comparable power, the new engine is lighter by about 35 to 40 kg, and is 30% more fuel efficient. Airmotive MD Richard Schulz adds that it can run on automotive grade petrol, bio-fuel, ethanol as well as aviation fuel, and with a service operating cost closer to a car engine than a GA engine. The successful development led to a further DST grant of R13,5 million for ADEPT, as well as various local and international awards – one of the latest being the AUTODESK International Innovator for the year award in 2009.

ADEPT Airmotive has made extensive use of the rapid prototyping facilities at CRPM in developing their new, light aircraft engine. From the manufacture of initial prototype models to test the fit and function of parts, to the use of grown LS sand moulds for prototype castings, ADEPT has depended on the accuracy and speed of CRPM's facilities. By using prototype sand moulds grown directly from 3D CAD data, ADEPT has been able to develop and test its aircraft engines, prior to spending vast sums of money on production tooling. Another advantage is that prototype moulds can be produced much faster than production tooling, leading to faster development times. Test results can then be used to optimise the design, and subsequent tooling.

For ADEPT Airmotive, CRPM's EOS S 700 LS platform is more than just a prototyping tool. It is also a useful production tool that supplied ADEPT with cores for complex castings as its aircraft engines enter full series production. The development would not have been possible without a triple helix success that included partnerships with the NRF, THRIP and Tshumisano, which have supported this project financially (De Beer, 2008). Figure 5 shows an image of the first prototype engine on a test bed.

Figure 5: Prototype engine development and testing



Patient specific implant development

Through promotion of research partnerships to establish accredited ways of using RP for medical product development, the IPD team was involved with a patient, who lost the major part of an elbow's bone through a road accident. Under normal circumstances, amputation would have been considered. The CUT team was contacted by Dr Hosking, and the road was paved for a rather unusual product development process. The patient's healthy arm was used as master pattern to develop a mirrored 3D prototype, using CT scanned images. A 3D model of the elbow was constructed from the imported 2D image slices from the CT scans, and used to build a physical model in CRPM's EOS P380 Laser Sintering machine. The process uses powder material and parts are built on a layered basis. Nylon Polyamide was used to build the mirrored geometry.

Satisfied that the prototypes accurately reproduced the patient's existing and injured (lost) elbow geometries, the biomedical engineer used the data and prototypes to start a parallel design process. Similar to the way in which an industrial designer would use clay, wood or polystyrene as modelling material, the team consisting of the surgeon and biomedical engineer used the nylon polyamide prototype to model the implant by removing the geometry that represents the patient's

lost bone, thus resulting in a physical representation of the injured bone. This was done on the same principle as the surgeon would have carried out bone surgery. The manipulated prototype was re-scanned to enable the development of the implant, using the original scanned data, together with added features, to machine a titanium implant.

The overall outcome of the project was a success. The patient has, to date, regained approximately 90% of the use of the injured arm within two months of the operation. The CT to CAD process is established, and works well. CAD images can be made available within 24 hours after receiving the CT scans. Prototyping becomes an automated function once the data are processed, and can be delivered within another 24 hours.

To gain more time for surgery and recovery of the patient, the team engaged in international research collaboration, to enable them to manufacture directly in titanium with an RP machine. The hypothesis was that it could speed up the reaction time and help to keep the digital competitive edge. Again, on the basis laid through successful technology transfer projects, an industry government partnership resulted in a THRIP grant of approximately R5,5 million that resulted in the development of a direct Ti sintering procedure, and has once more put a South African UoT in the forefront of research – both nationally and internationally (De Beer, 2005; Truscott *et al.*, 2007).

Rapid tooling development

In working with industry, CRPM often goes beyond normal service delivery, and seeks innovative solutions for current industrial problems. Technimark, an industrial partner to the CRPM, has successfully developed some pre-paid electricity meters, aimed at the international market. The tender process required the submission of injection-moulded parts to prove capacity to manufacture the product. Not knowing whether the tender would be successful, Technimark's development team decided to keep with standard commercially available or in-house parts, which meant they only had to introduce special jigs and fixtures to develop a risk-free new project.

The parts would, among other things, be used to hold electronic parts and PC boards. Four injection mould halves were needed, with fewer than four weeks available to manufacture – less than one-third of the conventional time needed for the manufacturing of a simple set of injection moulds (if no problems are experienced). If one takes the nature of the development and tender process into account, it was risky to commit expenses, leading to a conservative budget. The results, however, showed that the risks taken were worthwhile.

Instead of manufacturing complete moulds, Technimark, in collaboration with CRPM decided only to grow Alumide® inserts, which fitted into standard bolsters. Both the grown mould inserts and the bolsters were designed without any provision for cooling. Only basic mould finishing and polishing was done. The rib areas were finished to aid mould release. It required 23 hours of prototyping (one build volume), with four days of finishing and fitting. This meant that the injection-moulding could start in less than a week after finalising the design – a tooling world record!

Approximate mould costs were R23 000, as opposed to R90 000 with conventional methods. Technimark has done 30 trial samples in flame retardant ABS, which were followed up with the moulding of 800 further samples, for final (internal) use. Moulding was done on a standard 25 ton injection moulding machine.

Parallel trials were done in a 90 tonne injection-moulding machine, moulding standard tensile test pieces. During the parallel tests, a holding pressure of 15 bar and moulding temperature settings of up to 205°C were used (poly propylene). Again moulding was done without any cooling or air cooling.

This real industrial case study had to deal with challenging and complex part geometry. In terms of experimentation into Alumide® as a tooling medium, the part geometry was not accommodating. Compared to previous internationally published research results achieved on normal and plated epoxy tooling, the tools did not show the same failures such as cracks in the inserts, when ABS was used.

If, from a research and development point of view, one analyses the positive results achieved with the injection of flame retardant ABS in the Alumide® tooling, it is foreseen that even better results will be achieved through the provision of cooling channels, which is currently being experimented with. Rapid tooling (RT) solutions are generally niche applications. For applicable products, RT-solutions will result in accelerated product development, especially when used in a total concurrent product development environment – as RT alone will not result in faster product development. The availability of a material development such as Alumide®, however, is helping RT to gain acceptance as a competitive approach, and is helping to gain wider recognition for RT to become a standard production method in the accelerated product development process (De Beer *et al.*, 2006).

The availability of the new metal sintering technology will enhance RT results even more, and has already led to an international collaborative research programme between the CUT and the Technical University of Leiria in Portugal, to establish hybrid tooling.

As with the case studies discussed above, on the basis laid through successful technology transfer projects, an industry government partnership resulted in a THRIP grant of several million that resulted in the nylon sintering procedures. This was again backed by Tshumisano and NRF support (De Beer, 2006).

Conclusion

Without any doubt, it can be shown that research at UoTs contributes hugely to the knowledge economy, as well as providing innovative solutions to current-day industrial problems. The literature quoted as introductory research makes a number of suggestions, such as triple-helix partnerships between HEI with government and industry; inter-institutional partnerships and knowledge transfer; as well as an MIT-approach to research and development.

The case studies quoted in fact prove all of these principles, and have highlighted the tremendous future opportunities for UoTs when working with industry. Some of the issues not discussed in the case studies are the "by-products" resulting from the research, namely, input into R&D planning and management, continuing professional development of staff and students, as well as curriculum input. Referring back to Alwyn Louw's recommended MIT-approach and the gestures of new generation universities (2008), research niche areas formed in collaboration with industry have the potential to support cross-disciplinary focus learning areas such as courses in design, product development and manufacturing, thus once more addressing government priority areas.

> Industry has much to gain from higher education institutions in general. The spectrum of technology and innovation driven research programmes at UoTs, supported by active technology transfer initiatives, remains an untapped source of futuristic innovation.

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The new generation university: views on knowledge and knowledge generation

Dr Bernadette Johnson, Prof. Alwyn Louw and Dr Jan Smit

Abstract

A two-sector system has developed historically within higher education in South Africa, with some institutions known for being research intensive and others focused on application and teaching. However, it is argued in this article, by drawing on the work of Marshall (2006), that a different kind of university is needed, best captured by the notion of "new generation universities". These are universities that do not restrict their focus to teaching or research but develop an integrated approach informed by scholarship and an appreciation of multi-, inter- and trans-disciplinary research. They also develop knowledge partnerships which are relevant to societal needs.

Introduction

"As ivory towers crumble, traditional content-based, narrative-based, or apprenticeship-style education is becoming increasingly irrelevant", according to Axel Brunes *et al*. They are of the opinion that the competitive advantage of higher education now lies in its ability to provide a strong combination of systematic overviews and deep engagement with specific fields of knowledge.

The challenge for the higher education sector lies in its traditional binary character of the traditional university with a research and teaching mandate, and at the other end of the spectrum the traditional technical, career or vocational college with a focused teaching role. Over time, deep-seated discontent has been developing with aspects of this two-sector system.

The dissatisfaction stems from the growing awareness that the traditional role or values of both types could not meet the needs of a new kind of under- and postgraduate education. The unfilled gap seems to require a higher education arrangement that combines the approaches, focusing on instruction, community and industry response, open access, use of advisory groups, and work experience with the university scholarly environment. The efforts to address this need have led to a change: where degrees were traditionally the domain of the university system, they are now offered by various types of institutions.

The institutions focusing on developing programmes and services to fill the gap as described above are defined as the "new generation universities" (Marshall, 2006:3). These are "instructionally focused and scholarly informed" institutions which maintain the balance between teaching and research, as well as application.

Nature and characteristics of new generation universities

New generation universities "do different things". The different things span the main focus areas of teaching and learning, research and community service, but under a broader, integrated focus of serving society and more particularly their immediate communities.

New generation universities would thus offer a far greater set of learning programmes, covering a wider spectrum of qualifications, such as certificates, diplomas and degrees and, in some areas, do so from the initial entry level up to the PhD level. One of the challenges facing new generation universities is to develop learning pathways or articulation mechanisms between career-oriented certificate and diploma programmes and professional and other degree programmes.

This approach means that new generation universities offer discipline-based and inter- and multidisciplinary-based as well as trans-disciplinary learning programmes. It means that they are positioned to respond easily to changes in the knowledge environment such as the emergence of new knowledge areas like business ethics.

In the field of research, new generation universities are far more centred on problem-solving or user-inspired research, which relates to challenges faced by their constituent communities. The research of new generation universities is usually characterised by knowledge diffusion or technology transfer whereby the knowledge generated by researchers is infused into industry, business, government authorities or civil society.

These universities are characterised by engagement as the hallmark of their internal and external relations. In developing curricula they would engage with stakeholders, such as business, government and civil society, on the desired nature of the learning programme. They would include in such curricula teams, academics from disciplines other than the major ones in which a particular learning programme might be situated. Service learning and forms of experiential learning would form an important component of their educational delivery models.

Knowledge and the creation thereof in new generation universities

The core question is whether knowledge should be: 1) objectively gathered, reduced, reassembled and disseminated according to the scientific method; or 2) generated, through the cyclical application of theory to practice, by the practitioner, within a defined organisational setting (Lievano and Knudsen, 1997). In line with the growing critique of traditional university approaches to teaching, learning and research (knowledge creation and dissemination), it can be argued that mechanistic, "university defined" knowledge, corralled within rigid disciplinary structures, or within a few elite universities, has limited relevance to effective management of organisations in the 21st Century knowledge economy. Specifically, such knowledge is no longer adequate to address the complexities of time compressed, complex and dynamic problem-solving environments experienced in large public and private sector organisations. In essence, the locus of knowledge creation should be within the organisation at a nexus with customers, suppliers, other key stakeholders and learning partners such as universities.

The critique of traditional scientific views of knowledge production and dissemination is well supported at an ontological, epistemological and methodological level. At the first two levels the case for recognition of new forms of useful or applied knowledge is advanced in Gibbons' (1994) discussion of *Mode 1*, conventional scientific or functional knowledge, and *Mode 2*, trans-disciplinary, reflexive knowledge. Gibbons' argument is further developed by Leyesdorff and Etzkewitz on the role of universities within a fluid triple helix of institutional, market and societal innovation and knowledge creation (Leyesdorff and Etzkewitz, 2001). The case for alternatives to positivist knowledge production methodologies is well supported in the action learning theory (Emery, 1994) and advanced in practice through innovative pedagogical designs for courses (Mintzberg, 2005; Tellefsen, 1999).

Knowledge partnerships

Faced by restricting structures and agendas, the new generation universities are forced to build alternative funding bases and develop

and use knowledge partnerships with industry and government to achieve a clearly defined positioning and reputation in local, national and to some degree international markets for tertiary education. The approaches adopted by these institutions broadly correspond with a set of principles described by Lyons (2003) as the *High Cs of Partnership*, notably:

- Engaging in extensive and ongoing *Communication,* collaboration and networking activity;
- Establishing relationships which have enduring *Credibility* and relevance to both parties;
- Designating suitable *Champions*;
- Displaying substantial *Commitment* from both parties;
- Incorporating self *Critique* and review; and
- Acting as part of a *Community* or network of knowledge.

(Lyons, 2003, adapted from Wells, 2001).

Two other facilitating factors for successful knowledge partnerships include a deliberate policy of linking research and teaching to workplace practice, and creation of an independently funded, semi-autonomous centre to identify and build matrixes of expertise spanning functional silos within the university and its broader networks and establish an effective account management approach to ensure a coordinated and responsive approach to the needs of partner or client organisations.

Against this background it is possible to reflect more specifically on the possible research approach, contribution and role of new generation universities.

Strategic research: an opportunity for new generation universities

The focus in considering the research focus of new generation universities is to strive to bring wisdom and foresight into today's decisions and practices. New generation universities are distinct and different from the old generation universities, however, they draw upon their strengths where they remain relevant. As Norbert Elias, a sociologist concerned with Civilisation, Power and Knowledge argues, we have to encourage "detachment" in which we sufficiently remove ourselves from today's "normality" in order to consider what might be possible and therefore tomorrow's reality while this is born out of yesterday. In short: the *New* is born from the *Old*.

Given the applied research legacy of universities of technology in South Africa (previously referred to as technikons), they are typical new generation university type of institutions and as such suitably poised to take up a strategic research agenda (a combination of basic and use-inspired research, representative of the shift from Mode 1 to Mode 2 knowledge production). Their strength is that they already have links predominantly with industry, which inspired their initial inaugurations. However, these linkages have not been sufficiently deep to allow for the generation of new knowledge, while at traditional universities, often independent of industry and society, knowledge production has taken place with the benefit thereof, often evident much later.

Michael Gibbons, in the "new production of knowledge", argues that the challenge facing traditional universities is to organise themselves differently to allow the generation of new flexible networks which are orientated towards generating relevant knowledge or knowledge for immediate utilisation and not constricted by disciplinary borders and traditional fiefdoms. The opportunity available to new generation universities is that they are not burdened with having to navigate and negotiate established disciplinary boundaries. Old, established universities that are recognised and acclaimed as research intensive

and recognised as leading knowledge producing institutions are simultaneously shackled by hardened knowledge boundaries often based upon the leadership and personality of the godlike Professor. Often "he" is very difficult to question in re-orientating the research focus and agenda as his work, personality and life have become inextricably tied into his knowledge domain.

The new generation universities have an opportunity to establish within their foundations a research led teaching and learning approach. Increasingly, traditional universities have not adjusted timeously to the changing nature of society; at times de-linking research activity from teaching and learning. This new generation of universities must take note of and guard against such an approach. The Humboldt notion of the university, in which the relationship between teaching and learning and research is retained in the interest of generating appropriate knowledge and learning, must be retained. It is only through such a relation that new generation universities will ensure that their graduates are work-ready and community prepared.

Universities of technology as new generation universities have the added opportunity to focus knowledge production upon technology production and innovation. They essentially teach, learn, research and live technology. Whether from the initial vantage point of the social sciences or natural sciences, all scientific work within the university of technology should be geared towards the study of technology; creating relevant technology and ensuring the optimal utilisation of such technology so that technology is not just understood as a product but also its place and utilisation within a specific socio-political context. The orientation of the university of technology is therefore towards science and technology; not simply natural science and technology, but socio-natural science (inclusive) and technology. Essentially life does not happen in compartmentalised ways but in a dynamic, integrative, iterative way. The responsibility of the universities of technology is to show this through research and knowledge creation.

The nature/features of strategic research at new generation universities

To enable the immediate utilisation of research by society, the questions, problems and crises confronting society must inform the research agenda so that it is orientated towards solution and product generation. This requires a curriculum which is dynamic and permits product study at undergraduate level and interdisciplinary study at postgraduate level. Use-inspired and suitably knowledge orientated research should be created so that not only immediate solutions can be realised but the domain of knowledge itself expanded. While interrelated, these are essentially two distinct activities and processes which may best take place through the creation of distinct but related units with different levels of expertise. This would assist in not compromising basic research, the integrity of scientific research and the quality of teaching.

Through generating research from the development of strategic research areas or knowledge domains as the platform from which to attract appropriate human capital, new creative methodologies in the production of knowledge become possible. In this context, knowledge creation needs to be shaped and supported strategically if it is to be realised. Appropriate networks should be nurtured through which government, non-governmental organisations, industry and civil society should be given the opportunity to influence and shape the research agenda, which essentially would constitute *strategic collaborative research*.

The postmodern (in which power is dispersed and fragmented), post-industrial (in which manufacturing is not predominant), high-speed information generation (in which access to information is heightened) society in which we live requires universities to galvanise their resources towards the inclusive benefit of society in which the core of their activity is already socially distributed. The opportunity

for the new generation universities is that they can with greater ease link into existing socially distributed knowledge producing activities with the view to share, contribute and co-create rather than dominate and strive for centrality within knowledge creation. The continued massification of knowledge production and distribution will inevitably intensify the socially distributed nature of knowledge. The opportunity for the new generation universities is to become part of and party to this movement. In doing so these strategic linkages would be avenues through which postgraduate and continual professional development can be built, which would be of benefit not only to industry and society but critically to the university. Knowledge commons could be vehicles through which, for example, research and development forums with industry could ensure the continual relevance at a strategic level for the new generation university.

The era of globalisation or finance capital, in which stock markets and money capital dominated over manufacturing and actual production processes, is now starving society of financial capital as excessive and unregulated access has resulted in the crash of these financial markets. Scarcity is also abundant in food and natural resources such as energy. However, knowledge is the only commodity or resource which is in abundance. While society turns inward to seek opportunities for self-sustainability within nations and localised communities, current stock market crashes offer the new generation of universities a dynamic opportunity to generate the long-term sustainability of higher education through producing demand orientated knowledge as a driver for economic growth within globalised contexts.

Demand-orientated knowledge for new generation universities should be shaped by who is within their immediate vicinity. For example, Vaal University of Technology is in the company of SASOL, Mittal and Rand Water surrounded by extremely impoverished communities with high unemployment. The communities of various natures must stand to benefit from the knowledge activities at the new generation of universities, but most importantly large scale impoverished communities must be supported in seeking ways to generate their internal market forces and economic activity whether through the delivery of short training course or access to innovative production generation. Therefore the orientation while of immediate relevance to the surrounding communities should also be of value to South African society at large.

Demand-orientated knowledge requires research to be entrepreneurial. While the value of green fields research is indisputable as results will be derived (although at a much later stage), research that addresses immediate concerns unleashes the potential to create new opportunities. The resource of knowledge and therefore support for this should be derived from the entrepreneurial new generation university.

> If optimum benefit is to be derived from strategic research, a university which incorporates all disciplines or fields of study may not be most desirable. The immediate relevance and future orientation should inform the focus of the institution. This would allow for the opportunity to share and or investment into appropriate infrastructure, for example, equipment by industry and related agencies. To attract the confidence of such investors, the new generation university is corporate as its practices, processes and activities have to be carefully and appropriately designed along sound organisational and also viability principles.

Innovative knowledge creation at new generation universities

When considering the core business of the new generation universities, the innovative nature of knowledge requires fresh knowledge. Knowledge cannot be stagnant, it is not stable and cannot be easily derived from written texts as these usually are a record of what has already gone, what has already been discovered and has now become dated.

Knowledge is therefore understood as in flux, in creation, adaptable and malleable. While vast amounts of knowledge are available, being able to select relevant knowledge, understand and utilise the knowledge in context and create new knowledge from its derived benefits requires the innovative engagement with knowledge.

Creating knowledge and innovation centres is core to the new generation universities. Knowledge can no longer be as it has evolved within traditional universities, created with no regard for its distribution, utilisation and innovation in society. Knowledge and innovation centres provide the opportunity for knowledge to be co-created with the view to be commercialised as novel ideas and opportunities. Knowledge centres would be the initial incubators of such innovative processes, which upon maturation will be created into their own holding companies or spin-off opportunities to provide specialised services. Knowledge and innovation centres should retain their focus, for example, sustainable energy, food security, biotechnology, the environment, health or nanotechnology, while fostering opportunities for MIT research, which in turn telescopes the possibility to generate original incubators.

Knowledge and innovation centres have to be orientated to address real time demands and sufficiently insulated from bureaucratized processes and procedures which are not sufficiently responsive to the just-in-time, total-quality service and product delivery. Innovative academics or Leslie and Slaughter's academic capitalists have to understand that their business is creating and selling knowledge. Given this, the contentious issue of sharing of ownership and surpluses of intellectual property needs to be considered at the beginning of the relationship.

The operational arrangements of such knowledge and innovation centres are typically focused upon a core project, institute or centre which is the spoke characterised by a champion, with senior and junior researchers surrounded by hooks in which postgraduate students are placed. These are typically spin-off companies in which postgraduate students gain training and work integrated learning from which fresh research questions may arise from contextual application. The operational arrangements have to be inclusive and dynamic as they include networks with industry and other stakeholders as the project may require.

Primarily, remaining true to their name, the innovative centres have to be dynamic organisms which are able to change and redefine themselves, depending upon the specific requirements and orientations of the specific project and its components. Structures and processes have to be sufficiently flexible to accommodate and reorientate and recreate depending upon the demands and orientation of the project.

Predictive research at new generation universities

Being able to predict future scientific problems informed by the changing nature of society is critical in shaping current research agendas. This kind of work would require complex scientific modelling, forecasting and scenario generation to capture potential future problems and thereby potential futuristic solutions.

While globalisation has brought about the integration of vastness imaging the global village, it has also encouraged inward concentration upon local survival, needs and livelihoods. Traditional societal contradictions seem to persist and worsen, essentially encouraging focus upon local imperatives and the survival of the majority of humanity.

Predictive or forecasting research, informed by immediate pressing socio-scientific concerns such as resource viability and sustainability, has to be informed by how resources are produced, organised, accessed and distributed in increasingly cost effective ways across the masses in society. Undertaking scientific research for simplistic profit generation without sombre considerations of its socio-political-environmental implications would not constitute responsible research. Predictive research is therefore by its very nature MIT orientated.

The new generation of universities would need to consider whether individuals' worlds may become chronically localised in the absence of sustainable resources but virtually globalised as information and communication technologies provides continued access and improved circulation of human activity. In other words, would it be necessary to "go to work" in future? Would home become work and school? It is a society in which institutions that we know today no longer exist because insufficient natural resources prohibit expansion of existing infrastructures and limit mobility. What then might be the implications thereof for what is needed by society?

Knowledge production or research has evolved historically as a consequence of what society required. Therefore, it is rational to assume that predictive knowledge generation has to be informed by what we think or imagine society will need in the future.

Conclusion

The new generation universities have an extremely exciting role to play in society in the present and in the future. Whether these institutions are able to embrace their potential and opportunity is dependent on whether they can imagine new universities that are free and fresh to experiment, engage creatively with and dynamically respond to the real time needs and concerns of society, without getting lost in an undefined new space.

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Science, engineering and technology (SET) in universities of technology

Prof. Sibusiso Moyo

Abstract

Universities of technology (UoTs) must be the drivers of innovation and invention in the science, engineering and technology (SET) curriculum in the higher education sector. This would have an impact on the way the teaching, learning and research functions are designed and carried out in these institutions to distinguish them from comprehensive universities. The way the curriculum is designed would have to include the use of software packages, innovative teaching methodologies and allow for online learning and assessments, as well as work-integrated learning. Most programmes in the SET sector have to deal with the majority of students who are under-prepared for higher education with huge differences in their backgrounds. In particular, the under-preparedness of students in mathematics and the basic sciences poses a challenge for the higher education sector.

Here a brief discussion and perspective is given of some of the interventions that could enable UoTs to deal with the current challenges in the SET sector in order to become the drivers of technology and innovation among the higher education institutions (HEIs). Creative curriculum interventions can assist in dealing with the current

challenges and enhance the undergraduate experience in the SET curriculum at UoTs. A shift in focus from exam-oriented education to focusing on the quality of the education that is offered is suggested. In addition it is also pointed out that keeping abreast with current advances in technology also requires that the research and teaching focus and reforms for UoTs be on applied teaching and research.

Introduction

It is envisaged that the curriculum in a UoT sector should be technologically driven. That means that the way teaching, learning and research functions are designed takes into account requirements from industry. The effectiveness of the curriculum would be measured by employer satisfaction surveys with graduates and the ability of graduates to start up their own businesses. The measurement by industry of the quality of the graduates from the sector is usually assessed in terms of the ability of the student to execute the task at hand and the ability of the student to participate actively in innovation. This means students are expected to have strong analytical and communication skills.[1] In addition, if the sector is to meet the needs of industry adequately, then the sector should be flexible and have the ability to design curricula for short courses to meet the requirements of industry using the well-known "just in time" principle. The curriculum should be relevant to market needs, provide job readiness and include innovative educational approaches. The exposure of staff to industry can ensure that staff gain the industrial experience and keep abreast with new developments in technology. However, for the sector to be technology driven one needs huge investments in ensuring that it creates an environment which encourages creativity in both the sciences and engineering technology. The type of investment required to achieve the desired results would involve investing in the proper

1 Kjet van Rijswijk, 2009. Innovation and Training at Aerosud. South African Technology Network (SATN) Annual Conference, CPUT.

training of teachers at both primary and secondary school level in the basic sciences as this impacts on the preparedness of students entering the higher education sector. This is the level at which the foundation in science is supposed to start and hence the government as a whole needs to ensure that the relevant skills are developed at an early key stage. Secondly, the investment in training materials, training equipment and ensuring the existence of proper laboratories for experimental work are essential to ensure that effective teaching and learning take place.

The current challenge for higher education is the under-preparedness of students entering the SET sector. Despite all the underpinning challenges it is expected that the sector meets the Department of Education (DoE) benchmarks for throughput and graduation rates. One would want to know what reforms the new Department of Higher Education and Training (DHET) will put in place to redress the situation. We note that the majority of the under-prepared students in the basic sciences still come from mainly the under-privileged schools which are usually under-resourced.

Suggested funding categories for UoTs

The Department of Higher Education and Training should focus on increasing funding for the following categories:

- Funding into focused access programmes to the higher education sector for students with an under-prepared background.
- Funding for staff development programmes. For a start there should be a deliberate move to train staff at internationally established universities of technology. The reason is that the UoTs in South Africa are new, and UoTs mostly employ staff trained at traditional universities. UoTs require a pool of staff that has had the training and orientation at UoTs. The argument here is that we do not have the local capacity. Hence, there should be staff-development programmes at UoTs that attract the top students from UoTs, as well as traditional universities to be sent to do their masters and PhDs at well-established international UoTs to return to work in the UoT sector as well as industry. The ones who are employed in industry would still remain as alumni of the universities and also allow for opportunities for partnerships in research. This will give the sector a pool of staff with exposure to different and innovative ways of doing things. These would then provide a pool of staff that would be able to train the future technologists and understand what universities of technology actually are.
- Funding for expensive equipment to enable UoTs to carry out their current research and become more competitive at both national and international level.
- Investment in teaching and research grants.
- Investments in libraries and information systems within the UoTs.
- Increased funding for innovations and new technologies.
- Funding for setting up incubation centres to assist students and staff with their innovative ideas and start their own businesses within the university environment.

UoT staff profile

The emphasis in UoTs has been on creating staff capacity to ensure that there is appropriate capacity for teaching and carrying out applied research. However, this is still a challenge in some parts of the sector and benchmarks have been set to achieve the desired results in the next few years. For UoTs to be real drivers of the SET curriculum, the Department of Higher Education and Training would have to make heavy and focused investments. The UoT sector requires heavy funding for innovative staff development programmes and equipment in order to keep abreast with the world. The UoTs are appealing for various fits in line with the vision of the government. But the SET sector needs to be funded accordingly. The role of the government funding formula must be a martial plan for funding for UoTs. Since the DoE has set a benchmark which is higher than that of other universities for UoTs to produce engineers, it would be expected that the funding formula also takes into account how the required benchmarks are to be met. The challenge here is how institutions deal with the requirement to improve staff qualifications and retain highly trained staff at the same time. Perhaps the most effective way of attracting a high calibre of staff is to ensure that UoTs recruit the best qualified staff in the first place and remunerate them well and/or allow for third stream income opportunities.

Some suggested curriculum interventions

Here we acknowledge that it was possible to carry out the following interventions through the teaching development grant which was targeted towards trying to assist "at risk subjects" and improve their throughput rates at Durban University of Technology (DUT) in 2008. Here "at risk" subjects refers to subjects like Mathematics in which a higher percentage of students do not seem to perform better in comparison to other subjects. The following interventions are suggested:

- Introducing a structured tutorial system where tutors are available for consultation both during the week and weekends when students are free from attending other lectures and making tutorial attendance compulsory;
- Additional week-by-week exercises modelled on the prescribed text books with an option of using online assistance for the more difficult problems;
- Staff engagement with teaching and learning issues and challenges for both students and staff as the drivers of both the teaching and learning strategies;
- Using Mathematica, Scientific Workplace and other software as a tool for teaching and learning. The student feedback indicates that students find the subject more interesting if there is a software component in the curriculum that allows them to perform tasks independently and get immediate feedback on their results while having fun; and
- Teaching students in accordance with their aptitude. Student projects, assignments and use of e-learning as a tool for learning at one's own pace.

Improving student performance

To improve student performance in SET, the UoTs would need to be innovative in their approach. The provision of short courses during summer and winter breaks to do the foundations in mathematics and science courses required for students to succeed in their university careers could be seen as an intervention. In addition, the provision of learning centres well equipped with internet facilities and tutors so that learners can have a one-on-one meeting with the tutors is suggested.

In an excerpt from a recent review of "Mathematical Sciences Research at South African Universities"[2] it was pointed out that:

> "*…the importance of a sound foundation and research base in the mathematical sciences is absolutely critical for national development in science, engineering, commerce, and technology. Without this foundation, attempts at establishing a knowledge-based economy and generating innovation are doomed to failure. The development and transformation of human resources in science, engineering, and technology depend in a fundamental way on mathematical understanding, and a significant presence in each field of very highly skilled mathematicians.*" (DST, 2008)

2 DST (Department of Science and Technology), 2008. Review of Mathematical Sciences Research at South African Higher Education Institutions. International Review Report. DST website, International Review panel.

The panel pointed out the need of increasing PhDs five times more than the current output rate in order to create the capacity needed to carry out the required teaching and research functions. The current research is done by a small group of NRF-rated researchers who are thinly spread across the sector and the most critical concern was that nationally the critical mass of researchers is in the 55+ age group.

Finally, one asks the question of how UoTs will distinguish themselves from other universities and establish themselves as innovative and technologically advanced leaders among the higher education sector. According to the HEMIS data for 2006, the participation rate in the SET sector was captured at around 35%. The second question is how UoTs will reposition themselves to ensure that there are increased enrolments that attract particularly students from the previously disadvantaged populations, where the need is greater, while insisting that the entry requirements are met. The challenge for UoTs is still to provide an increasing number of high calibre graduates.[3]

> The following quotation summarises the fact that we do not have to try to become what we are not as UoTs but to reposition ourselves as drivers and significant players in the Science, Engineering and Technology sector: "I took the road less travelled by, and that has made all the difference." (Robert Frost)

Participation rates in SET

The data in Tables 1-2 shows participation rates in the SET sector in comparison to other areas like business, commerce, education and other humanities. This data is collected from the HEMIS3 database.[4]

3 SATN (South African Technology Network), 2008. Final report on the project pertaining to the development of performance indicators for UoTs and UoT-related parts of comprehensive universities.

4 HEMIS DATABASE, 2008. DoE website: www.education.gov.za

Table 1: Headcount of unduplicated enrolments according to categories of major(s)/area of specialisation by African females

HUMAN OR NATURAL SCIENCES	OCCA-SIONAL	UG DIP/ CERT (1 or 2yrs)	UG DIP/ CERT (3yrs)	MASTERS/ MASTERS DIP	DOCT-ORATE	TOTAL	%TOTAL
Human sciences	6 562.25	33 691.33	55 296.25	5 796.92	713.50	102 060.25	77.18388
Natural sciences	1 807.75	1 803.67	23 248.75	2 768.08	481.50	30 109.75	22.77074
Unknown	45.00	0.00	6.00	7.00	2.00	60.00	0.045375
TOTAL (Fractional counts)	**8 415.00**	**35 495.00**	**78 551.00**	**8 572.00**	**1 197.00**	**132 230.00**	

Table 2

VARIOUS CESM	OCCA-SIONAL	UG DIP/ CERT (1 or 2yrs)	UG DIP/ CERT (3yrs)	MASTERS/ MASTERS DIP	DOCT-ORATE	TOTAL	%TOTAL
SET	1 807.75	1 803.67	23 248.75	2 768.08	481.50	30 109.75	22.77074
Business and commerce	1 613.67	8 722.42	33 290.25	1 471.83	44.00	45 142.17	34.13913
Education	215.25	23 766.17	5 862.17	1 600.25	218.00	31 661.83	23.94452
Other humanities	4 733.33	1 202.75	16 143.83	2 724.83	451.50	25 256.25	19.10024
Unknown	45.00	0.00	6.00	7.00	2.00	60.00	0.045375
TOTAL (Fractional counts)	**8 415.00**	**35 495.00**	**78 551.00**	**8 572.00**	**1 197.00**	**132 230.00**	

The data above shows the actual enrolments in the SET sector as captured in 2007 in comparison to the other fields like business, commerce, education and other humanities. This information is taken across the whole of the higher education sector. From Table 1, we observe that the natural sciences enrolments across all universities stood at about 23% in comparison to the 77% students who went into the human sciences. What is of interest is the percentage of students who go on to enrol for their higher degrees at master's and doctoral levels. This shows a very small percentage as around 9 769 students out of the 132 230 would have gone on to enrol for either a master's or doctoral degree. This also explains why the nation as a whole is not producing enough graduates at the doctoral level to engage in research and innovation. In Table 2, we also point out that only about 23% of the black female students enrol in the SET sector across all higher education institutions.

Table 3 shows the number of students (all genders) who fulfilled their degree requirements across all universities. Of all the enrolments, 81% of those students who go into the human sciences fulfil their degree requirements while only 18% manage to do this in the natural sciences. We also note that there is increased funding for outputs at postgraduate level but the participation rates at this level, particularly in the SET sector, need to be increased.

As a case study, we use some sample data collected from one of the universities of technology over a 5-year cycle, to show the current trends in enrolment rates and success rates per gender. While this sample does not represent all other UoTs, it illustrates on the average trends in student enrolments versus graduation rates in the SET sector.

Table 3: Number of students who fulfilled the requirements for a degree/diploma/certificate

HUMAN OR NATURAL SCIENCES	UG DIP/ CERT (1 or 2yrs)	UG DIP/ CERT (3yrs)	UG B. DEGS (1st B Deg 3yrs)	MASTERS/ MASTERS DIP. RESEARCH	MASTERS/ MASTERS DIP. NON-RESEARCH	DOCT-ORATE	TOTAL
Human sciences	9 728.42	8 976.75	5 154.17	342.30	482.53	60.00	24 744.17
Natural sciences	552.58	2 938.25	1 569.83	228.43	131.74	47.00	5 467.83
Unknown	1.00	5.00	2.00	0.00	0.00	0.00	8.00
TOTAL (Fractional counts)	**10 282.00**	**11 920.00**	**6 726.00**	**570.73**	**614.27**	**107.00**	**30 220.00**

VARIOUS CESM	UG DIP/ CERT (1 or 2yrs)	UG DIP/ CERT (3yrs)	UG B. DEGS (1st B. Deg 3yrs)	MASTERS/ MASTERS DIP RESEARCH	MASTERS/ MASTERS DIP NON-RESEARCH	DOCT-ORATE	TOTAL
SET	552.58	2 938.25	1 569.83	228.43	131.74	47.00	5 467.83
Business and commerce	854.75	4 680.58	2 045.17	33.00	192.25	2.00	7 807.75
Education	8 720.58	2 461.92	115.25	85.97	60.53	25.00	11 469.25
Other humanities	153.08	1 834.25	2 993.75	223.32	229.76	33.00	5 467.17
Unknown	1.00	5.00	2.00	0.00	0.00	0.00	8.00
TOTAL (Fractional counts)	**10 282.00**	**11 920.00**	**6 726.00**	**570.73**	**614.27**	**107.00**	**30 220.00**

Table 4: Enrolment numbers for SET per gender group

Gender with CESM	2004	2005	2006	2007	2008	Average annual growth: 2004 to 2008	Change: 2007 compared to 2008
SET	**12 714**	**12 873**	**13 041**	**13 253**	**13 768**	**2.0%**	**3.9%**
Female	4 510	4 624	4 886	5 127	5 558	5.4%	8.4%
Male	8 203	8 249	8 155	8 126	8 209	0.0%	1.0%

Figure 1 below illustrates the information in Table 4 above and shows the comparison in the growth rates from 2004 to 2008 in student enrolments in the SET sector at Cape Peninsula University of Technology (CPUT). Series 1 shows the number of female enrolments and Series 3 shows the number of male enrolments. The average annual growth rates are given in Table 4. It is important to observe that there is a general growth rate of female students from 2007 to 2008.

Figure 1: Enrolments by gender – 2008

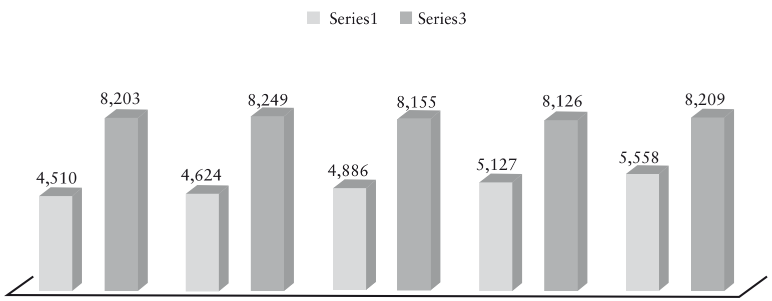

Table 5: SET graduation rates for the SET sector per gender group

Gender within CESM	2004	2005	2006	2007	2008	Average annual growth: 2004 to 2008	Change: 2007 compared to 2008
SET	**2 517**	**2 586**	**2 840**	**2 794**	**2 818**	**2.9%**	**0.9%**
Female	1 009	1 024	1 131	1 148	1 205	4.5%	5.0%
Male	1 508	1 562	1 709	1 646	1 614	1.7%	-2.0%

In comparison to the enrolment rates there is a significant drop in the graduation rates in the SET sector. The development indicators recently established by the South African Technology Network (SATN) can be used to compare the performance of the UoTs among each other and with other traditional universities. We further take a look at the postgraduate enrolment rates and graduation rates. Table 6 below shows the postgraduate enrolments for female students of all races.

Table 6: Postgraduate enrolments in the SET sector

Qualification type within gender	2004	2005	2006	2007	2008	Average annual growth: 2004 to 2008	Change: 2007 compared to 2008
Female							
Baccalaureus technologiae degree	633	775	1 077	1 289	1 527	24.6%	18.4%
Doctor technologiae degree	8	7	9	10	13	12.9%	30.0%
Magister technologiae degree	54	56	68	94	98	16.1%	4.3%

Table 7: Postgraduate enrolments males in the SET sector

Qualification type within gender	2004	2005	2006	2007	2008	Average annual growth: 2004 to 2008	Change: 2007 compared to 2008
Male	**8 203**	**8 249**	**8 155**	**8 126**	**8 209**	**0.0%**	**1.0%**
Baccalaureus technologiae degree	1 019	1 141	1 196	1 301	1 334	7.0%	2.5%
Doctor technologiae degree	27	33	48	35	38	8.9%	8.6%
Magister technologiae degree	135	154	187	166	179	7.3%	7.8%

Table 7 also shows the enrolment rates for male students at postgraduate level over the last five years at CPUT. In comparison to the females, more males enrolled in 2008. The growth rate for female participants, however, is higher than the male growth rate, particularly at doctorate level, and lower for females at masters level.

The challenge for UoTs still remains for them to increase participation rates from all population groups and improve the success rates in the SET sector. Further research and data need to be collected by UoTs to look into the current status of SET at UoTs, with particular reference to the existing infrastructure, curriculum and funding. However, with the current enrolment targets expected by the government to be at 50%,[5] there are further constraints on the sector to compete with already established universities with existing infrastructure. Hence, it is expected that UoTs through the SATN, will put pressure on the DHET to ensure that there is increased funding towards the SET sector in all the UoTs.

5 Roy du Pré, 2009. The Place and Role of Universities of Technology in South Africa. Bloemfontein: SATN.

SET challenges – external and internal

We note that the SET sector still faces challenges in retaining postgraduate candidates, particularly blacks, as well as research expertise after retirement in the SET sector in higher education. According to the information captured in the National Research Foundation's vision for 2015,[6] it is apparent that there is a political awareness of the importance of science and engineering technology in order for the larger population to participate in technology and innovation. However, the challenge is that there is still poor quality schooling for the larger population. This impacts on the human resource shortages at all levels including mathematics, science, engineering and technology. In addition, there is a lack of design, engineering, entrepreneurial and management (DEEM) actors and a lack of research and development capacity, which gives rise to an "engineering gap". The governance and strategic implementation of the state components of the innovation system is insufficiently holistic. In shaping the UoTs, there is therefore an opportunity to reposition the UoT sector as a significant role player in the SET sector by contributing to addressing skill shortages in partnership and in line with the government targets.

Global recession, poverty and inequality across the South African economy still pose a threat to the social well being of all South Africans. Hence, the contribution of UoTs to addressing the national problems of increased energy efficiency and other projects also addressing real problems faced by the society will be of great value.

Conclusion

In conclusion, UoTs need to position themselves as the drivers of the SET sector and benchmark both nationally and internationally.

6 NRF, 2008, Strategic plan of the National Research Foundation (NRF), www.nrf.ac.za

However, there are still many challenges which universities of technology in South Africa have to deal with. Firstly, the under-preparedness of students who come into the SET sector from previously disadvantaged backgrounds and the expectation to ensure that the sector produces high quality, job-ready graduates. There would have to be growth particularly in the applied sciences in order to create more capable participants in the SET sector. The current strength for UoTs is their links with industry, which still need to be increased. A strong foundation in the basic applied sciences will enable the sector to engage effectively in applied research while preparing work ready graduates who are able to contribute to the social upliftment of the societies they live in.

It is expected that the SATN will address some of the challenges facing the sector by engaging with the relevant role players in dealing with the issues. In a recent Minister's address,[7] at the SATN conference held at Cape Peninsula University of Technology in July 2009, it was pointed out that the South African education system has structures, mechanisms and funds available for SET but there is a lack of coherence in the approach in dealing with innovation, research and development. Furthermore, the Minister pointed out that UoTs need to play an increased role in ensuring that the number of skilled researchers in technology is increased in South Africa. It is also expected that the SATN would play an important role in informing the Ministry on what is required to improve the human resource base. The UoT sector was encouraged to take advantage of and engage more with the departments that deal with science and innovation like the NRF, the Department of Trade and Industry (DTI), and the Department of Science and Technology (DST), just to mention a few.

In the same address it was pointed out that UoTs need to focus on the production, commercialisation and management of innovation. Furthermore, the sector is expected to develop staff research profiles and capacity within the universities. The concept of "differentiation",

7 Naledi Pandor, 2009. Minister's speech, Department of Science and Technology. SATN annual conference, CPUT. Cape Town, South Africa.

as mentioned in the speech, is part of the national agenda. However, it is important that the sector does not perceive differentiation as being inferior but as a tool that helps the sector identify and focus on niche areas and areas of strength. In doing this, it would be expected that the sector also maintain and improve its already existing strength in excellence in teaching.

UoTs have put in place systems to try to improve the qualifications and profiles of their staff. However, the performance indicators developed for the UoTs will assist in measuring the performance in the sector in the various identified areas. At the same time it is expected that a review of the investment so far by the Ministry of Higher Education and Training will be carried out in order to measure the impact.

Finally, UoTs have made significant steps in ensuring that their presence is felt. However, in the SET sector, UoTs need to be funded accordingly, participate in the South African Research Chairs Initiative, and participate in creating centres of excellence and competence. UoTs, through the SATN, should assist the government and the Department of Science and Technology in articulating policy implementation and pronouncing on delivery so that there is visible progress and impact in the SET sector.

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External regulation and the universities of technology

Lesley Anne Cooke, Dhaya Naidoo and Kalawathie Sattar

> *"The university we have today is no accident; rather, it is a product of history, culture, and public and private demand."* (Johnstone, 1999)

Abstract

The higher education sector in South Africa has faced enormous challenges and changes since the birth of a new democracy in 1994. From the perspective of the universities of technology, striving to establish a new identity has amplified these challenges.

This paper focuses on the impact of historical antecedents of legislated external regulation in universities of technology on the development of quality assurance in this sector. Against the backdrop of a new identity and the promulgation of the Higher Education Qualifications Framework, the notion of collaborative regulation is explored as well as the concept of quality vis-à-vis "qualities" and performance indicators.

Introduction

At a national level, various forms of formal regulatory mechanisms have existed in the vocational and technical higher education sector as it evolved from Colleges of Advanced Technical Education (CATE) to the current universities of technology (UoTs) (CHE, 2000). This experience of external regulation has been perceived as a strength as evidenced by the willingness of the sector to embrace external regulatory systems readily albeit somewhat uncritically.

This article explores the historical antecedents for external quality assurance (QA) in the UoTs,[1] the subsequent implementation of a "uniform" national system for QA across all higher education institutions, the implications of national systems and imperatives for UoTs and the meaning of quality in this context. The authors do not presume to raise questions around the nomenclature or the status of universities of technology; rather, it is taken as a matter of fact that the landscape of South African higher education embraces the UoTs.

However, the history of South African higher education is steeped in politics and inequality, and cognisance must be taken of the fact that the UoTs themselves did not emerge from a homogeneous group of institutions. The political ideology at the time supported purposeful and differential allocation of, *inter alia*, financial resources to designated higher education institutions. This resulted in tensions in the higher education sector and created negative public perceptions about the status and standing, as well as the quality of graduates of some universities and technikons; a legacy that took these institutions years to overcome.

Consequently, the early history of the UoT sector, which may be ascribed to regulatory national policies, is more about control of the curriculum than about quality assurance and improvement. Therefore, the challenge of defining quality in a UoT cannot be

1 In the context of this article, the designation university of technology (UoT) is inclusive of the previous forms of this higher education type. Therefore, it embraces the CATEs and the technikons.

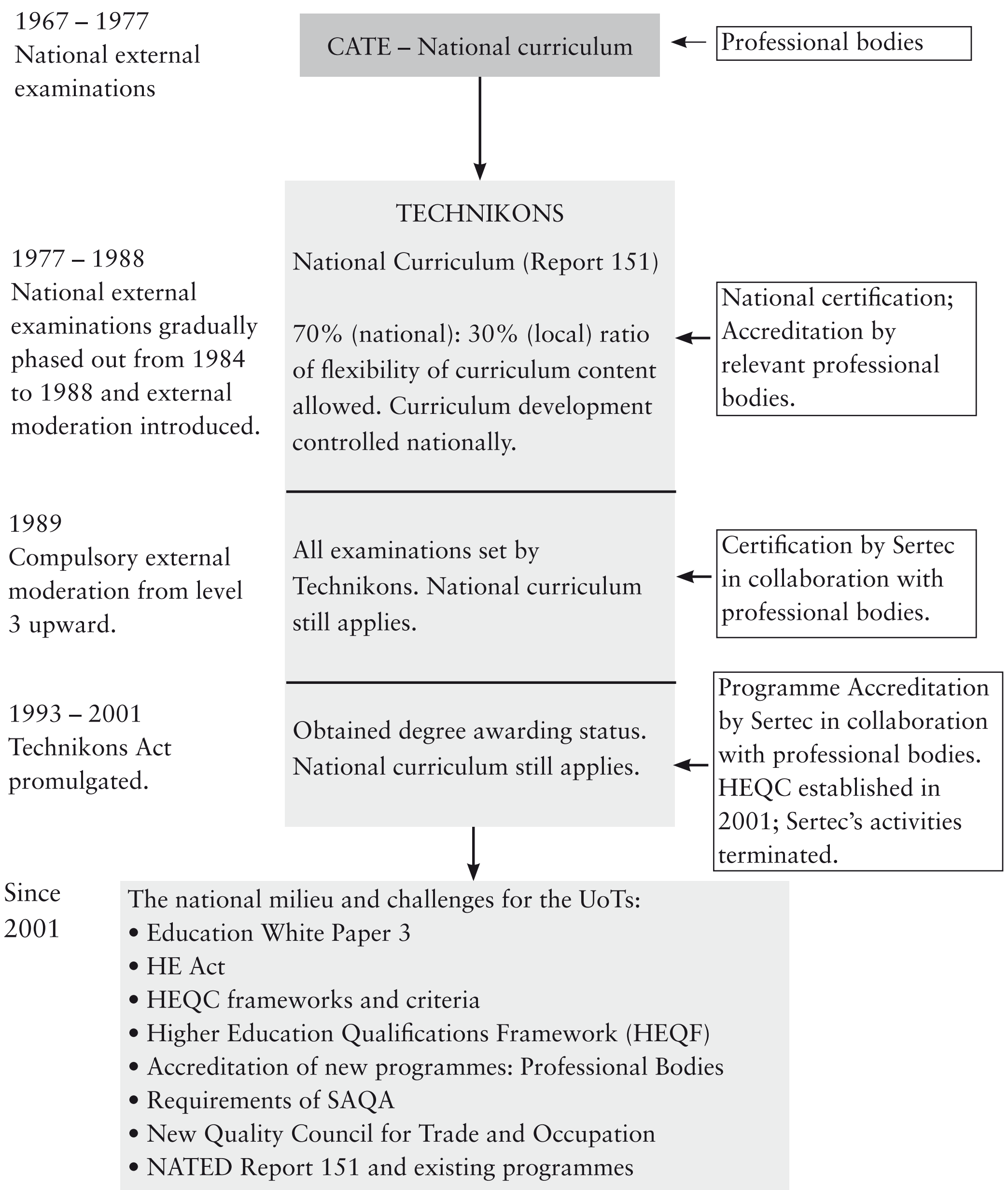
viewed in isolation from the politics of quality assurance and notions of "democratising quality".

Historical context: external regulation of universities of technology

Some insight into the historical development of external regulation at UoTs is necessary as it sets the context for quality assurance in the sector. The UoTs have weathered a spectrum of approaches from rigid central control and regulation specific to the sector, to the current quality assurance system applicable to all higher education institutions in South Africa (see Figure 1).

During the period 1969 to 1979, the curricula of academic programmes offered at the CATEs were centrally developed and controlled by the national Department of Education. No changes could be made to the national curriculum without prior approval through very complex and controlling structures since qualifications were usually prefaced by "national" as in *National Diploma* or *National Certificate*. In many cases, professional bodies wielded greater influence on curriculum content than the academics who taught these programmes. All examinations were controlled nationally, that is, national examiners were responsible for setting examination papers that were written by all students across the country. Examination scripts were marked and moderated centrally by national examiners and moderators.

Figure 1: Evolution and external regulation of the UoTs (adapted from Sattar, 2001)



In 1979, the CATEs underwent a name change to technikons.[2] Between 1979 and 1988, national examinations were gradually phased out; individual institutions were now able to set their own examinations and compulsory external moderation of examinations was managed by each institution. The curriculum was still nationally controlled, and institutions were not allowed to deviate from the curriculum that was approved by the Department of Education and documented in NATED Report 151[3]. In 1986, some local control was devolved to institutions whereby they were able to adapt 30% of the curriculum to accommodate "local content". The professional bodies especially vigorously controlled 70% of the curriculum content. The shift in the locus of control of the examinations to the institutions afforded academics a tantalising glimpse of a possible future where they might have greater autonomy over the curriculum.

From the preceding narrative, it is apparent that between 1969 and 1988 there was a heavy emphasis on control of the curriculum. Quality assurance *per se* was not an overt feature at a systemic level and the control of the curriculum in the UoT sector mirrored the prevailing political context of control in the country at the time. While the emphasis on quality in higher education gathered momentum in the last decade of the previous century, this sector in South African higher education was highly regulated to conform to the requirements of NATED Reports 150 and 151.

The Certification Council for Technikon Education (SERTEC) was established with the promulgation of the SERTEC Act no. 88 of 1986 and, in collaboration with professional bodies, was involved in

2 In March 2002 there were 15 technikons. This number was significantly reduced to five UoTs through the merging of institutions.

3 The two documents that regulated the programmes and qualifications in the sector were the General Policy for Technikon Instructional Programmes: NATED Report 150 and the Formal Technikon Instructional Programmes in the RSA: NATED Report 151. Report 150 provided a framework for the qualification types and their descriptions. Report 151 documented the structure of the learning programmes by stipulating the names of the subjects and their credits. These frameworks were replaced by the HEQF which was promulgated in 2008 (Government Gazette, October 2007).

certification from this time. In 1993, this collaborative relationship was extended to include programme accreditation.[4] From 1996, the focus of the Certification Council shifted to self-evaluation as the basis for educational quality monitoring and partial institutional "audits" were also conducted.

The extent to which UoTs were "overregulated" prior to 2001 is further evident when the historical effect of national control over the curriculum is juxtaposed with the prevailing context for quality assurance. The approach by the Certification Council was described as "overly mechanistic and unlikely to encourage the development of strong and confident institutional quality management systems" (Reddy *et al*., 2000, p. 34). Furthermore, the approach to self-evaluation at the programme level did not promote quality improvement at an institutional level. Thus, one might argue that in contrast to the conceptualisation of quality as transformation, fitness for purpose and value for money (Harvey and Knight, 1995), up to 2001, the approach to quality in the UoTs was more akin to quality control.

Signals for fresh approaches to quality and quality assurance were evident following the establishment of the Higher Education Quality Committee (HEQC) in 2001 as a permanent sub-committee of the Council for Higher Education (CHE). This watershed moment was also marked by the activities of the Certification Council coming to an end, imperatives for institutions to merge, and the Committee of Technikon Principals (CTP) beginning to advocate a change in the designation of technikons to that of universities of technology (Committee of Technikon Principals, 2001). These changes brought to the fore the hopes and aspirations of the sector for increased freedom and autonomy with regard to (a) establishing, monitoring and maintaining academic standards and (b) a concomitant decrease in national control of the curriculum.

4 The UoT sector was granted degree-awarding status in 1993 with the promulgation of the Technikons Act.

Communities of practice: the role of the convenors

The CTP played a key role for the sector in the approval of new programmes by the Department of Education prior to such programmes being included in Report 151. Institutions were only able to apply to the Certification Council for the accreditation of new programmes once inclusion in Report 151 had been effected. The minimum turnaround time for the approval and accreditation of a new programme was 18 months to two years.[5] The impact of these protracted processes included constraints with regard to the continued relevance of approved programmes, and frustration among industry partners.

In the early 1980s, in an attempt to mitigate the possible negative impact of centralist control by the Department of Education, the CTP established a system of "convenorship", whereby selected institutions were given increasing responsibility for leading curriculum development initiatives for specific programmes. The convenors were also instrumental in driving the initiatives that culminated in the interim registration of qualifications with SAQA. By the end of 2003, the "convenor" system was ultimately disbanded. It is unfortunate that the full potential of the convenor system was not formally realised as developments in the national higher education system gained momentum.

While this centrally managed process was well intentioned with regard to the greater good of the UoTs, when coupled with the evolving national milieu, it may ultimately have contributed to the disempowerment of academic staff at institutional level with regard to input into, and changes to, the curriculum. On the one hand, the well-intentioned spirit in which the convenorships were established appears to resonate with the notion that consent is a major feature

5 The processes for the approval and accreditation of new programmes and changes to existing programmes required the convenor institution to collaborate with all UoTs in the completion of the required documentation and to obtain their approval prior to the submission of the documents to the Certification Council via the CTP.

of democracy and that participation in deliberation is necessary if decisions and directives are not to be coercively imposed (Enslin, Pendlebury and Tjiattas, 2003).

On the other hand, the selection of "convenor" institutions by the CTP was perceived by some to be an attempt to maintain the status quo of centralised control through "better" institutions being nominated to adopt the leadership role. It is plausible that disempowerment may ensue if deliberations become skewed towards the views or "norms" of a dominant institution, thus allowing the latter to manipulate activities to further its own ends (Enslin, Pendlebury and Tjiattas, 2003).

It is notable that, after the disbanding of the convenor system, many UoTs continued to collaborate informally both with each other and with the relevant professional bodies as communities of practice in relationships where the cornerstones are a professional identity and ethos. Typically, key activities focus on the relevance of academic programmes, the development of new programmes and, generally, the enhancement of academic standards albeit not in an explicit manner. There is now a groundswell of support for the return of the "convenor" system as a formally constituted consultative forum rather than as the current loose affiliation.

The challenges of implementation of the higher education qualifications framework

The Higher Education Qualifications Framework (HEQF), promulgated in October 2008, brings with it a fresh set of challenges for the UoTs which will ultimately impact on curriculum development and quality assurance. In particular, issues pertaining to access to both higher education and to postgraduate studies emerge. With regard to

the former, the UoTs in particular have always been responsive to the goals of the White Paper (1997). The UoTs offer access to higher education for large numbers of students who have the potential to succeed but who otherwise would not be able to embark on studies at this level.

The latter issue relates to the qualification types that may be offered at a UoT and the concomitant impact that these qualifications will have on progression within higher education. In 1993, the UoTs were granted degree-awarding status and proceeded to develop and offer specific bachelor's degrees. These BTech degrees were whole qualifications of one-year duration which, coupled with the relevant pre-requisite diploma, allowed access to postgraduate qualifications at the master's level. Thus the qualification types offered by the UoT sector facilitate progression of these students from a diploma to masters and ultimately doctoral studies.

The implementation of the HEQF in its current format will require additional study time of two to three years for student progression to postgraduate level. Furthermore, should the profile of qualification types offered by the UoTs shift to become predominantly first degrees, the impact on access to higher education would be disastrous unless supported by the provision of more robust student academic support in the form of, for example, foundation programmes. Thus, the possible impact of the HEQF on quality and academic standards has to be rigorously interrogated given the increasing level of complexity introduced into the HE system, not least of which have been the recent changes within the Ministry for Education.

It is evident that the implementation of the HEQF in the UoT sector begs questions around the sweeping curriculum reform that will be required and the implications thereof for academic standards and quality assurance. Concerns around these issues are amplified in the context of the uncertainty created by the addition of a new standards setting responsibility for the HEQC. Some considerations in this regard are explored below.

Collaborative regulation (is this possible?)

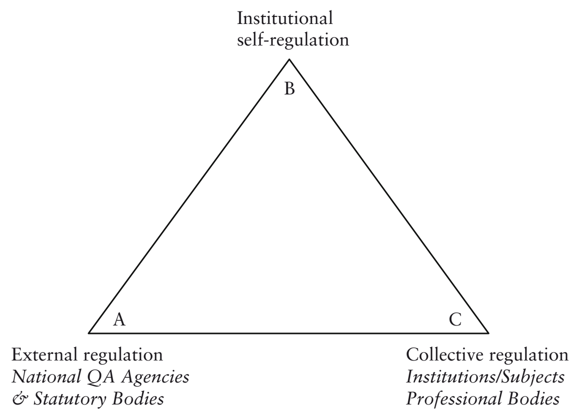
The establishment of the HEQC in 2001, with its dual mandate for programme accreditation and institutional audit, was welcomed by the UoTs since all higher education institutions would be regulated by the same systems and processes. One anticipated impact was a greater emphasis on self- (internal) regulation.

However, given the history of regulation and control that UoTs have experienced, the question that arises is: *Where might the balance of regulatory control lie?* In the context of universities in the United Kingdom, Jackson (1998) refers to a "partnership in trust" and considers strategies for the establishment of such a partnership which has a bearing on regulatory control. He goes on to explain that:

> "*such a partnership in trust would place the onus on institutions to demonstrate that they had in place explicit, comprehensive, reliable and effective mechanisms for assuring the quality of their education and academic standards, and which protected the interests of the various constituencies they served. Once this condition had been demonstrated national external regulators would trust the institution to maintain its capacity for self-regulation and reduce the requirement for public accountability via external review*." (Jackson, 1998, p. 7)

Jackson's model for achieving a balance of control is predicated on a history of conformance with national requirements, which he argues is necessary for the development of a culture of quality assurance. Therefore, it is only when there is maturity at a systemic level that one can contemplate models that promote greater self-regulation. As can be seen from Figure 2, the model he articulates is a continuum with self-regulation (institutional), external regulation (national QA agencies) and collective regulation (institutional and professional bodies) expressed as an equilateral triangle.

Figure 2: The balance of regulatory control within the national framework (Jackson, 1998, p. 6)



In the South African context, such a fledgling relationship may well exist at a systemic level at the UoTs but might be very superficial. Furthermore, the authors have noted that at an institutional and specifically at programme level, the tensions in the system as a result of where the balance of control lies forces the triangle to change shape such that it is no longer an equilateral triangle.

The model described by Jackson (1998) may be appropriate for those universities in the UK that have self-accreditation status. In South Africa this does not apply: the accreditation of new programmes is the responsibility of the external quality assurance agency, the HEQC. Considering the implications of the HEQF for the development and accreditation of new programmes at all the UoTs, the national system is in danger of being overwhelmed. The impact of the implementation of the Bologna process on universities in Europe is an example of system-wide curriculum reform that threatens the integrity of the HE system because of the complexity and extent of change required (Crosier, Purser and Smidt, 2007). Perhaps it is time to re-consider the South African national system for programme accreditation and whether it is appropriate for a changing context.

In a report regarding the degree structure and the progress made by universities in Europe in implementing the Bologna reforms, institutions have expressed concerns about "insufficient institutional autonomy to implement reforms in a way in which they would be most effective" (Crosier, Purser and Smidt, 2007). In the same report, academics also questioned "how they could be expected to make radical changes to their thinking about curriculum, at the same time as adapting to more rigorous quality demands". These comments certainly resonate within the South African context where higher education is subject to steering from a national level.

This theme is further illuminated by Barnett (2003), who asserts that the newer ideologies of quality, managerialism and entrepreneurship in higher education have become more pervasive. He maintains that these ideologies have percolated into the discourse on higher education because governments no longer trust higher education institutions. The source of this distrust perhaps lies in the range of stakeholders with competing (and co-operative) interests trying to impose these on higher education.

This sense of institutions being overwhelmed at all levels by the compelling demands for curriculum reform and quality assurance is eloquently captured in the quotation below:

> "*… a plethora of regulatory bodies, making competing and sometimes contradictory demands on universities. If academics spend increasing amounts of their time servicing these demands, then, even if individually each set of demands is reasonable, the definitive work of universities will be undermined. Excessive regulation threatens to corrupt the practice and exhaust and demoralise its practitioners. The practice and its traditions, and the possibility for changing those traditions are lost where practitioners no longer have the time to immerse themselves in the practice.*" (Enslin, Pendlebury and Tjiattas, 2003, p. 80)

Given all of the above, one question to ponder is this: does the current national system of quality assurance perpetuate central control?

Defining quality in a UoT

The vexing challenges of defining quality in higher education are well documented in the literature, for example, Westhuizen and Fourie (2002) note that:

> "*Notions of quality, purposes and procedures of quality assurance, as well as the scope and level of quality reviews differ from country to country depending on the national and systemic context in which higher education operates.*" (Westhuizen and Fourie, 2002, p. 3)

In the South African context, a definition of quality cannot be separated from the politics of quality, which raises critical issues around redress and delivering quality education. Such a definition has to be located within a context that takes cognisance of structure, history and ideology (Harvey, 1999). In writing about the democratisaton of quality, Harvey (2009) is critical of the South African approach to quality assurance and comments that "fitness for purpose is not so benign… [it] is directly systematised in the checking of the fitness *of* purpose … [there is] a softening, therefore, that is a sham democratically". He questions democracy in the context of quality assurance and whether there is "… tolerance, fairness a sense of rights preserved? … Does the power reside behind the scenes?" (Harvey, 2009, p. 6)

The general critique offered by Harvey (2009) of the systems of external quality assurance with or without consultation with stakeholders concludes that "…there is not much sign of democracy". Harvey maintains that "... "democratising quality" is shorthand for a desire for an empowering and enhancing transformative quality higher education that underpins the fundamental elements of democracy" (Harvey, 2009, p. 9).

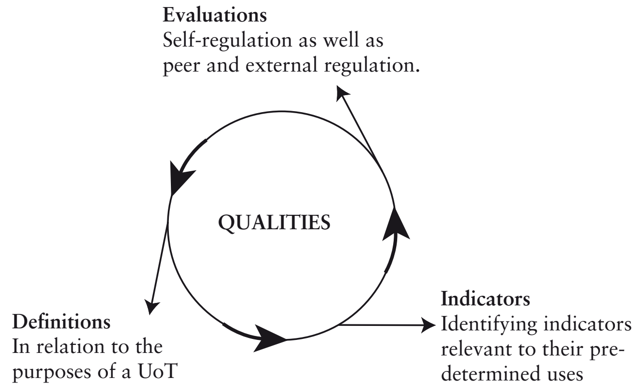
The context for HE in South Africa is highly politicised and the situation is exacerbated by the overt steering of the HE system by government. While the notion of steering higher education is couched in more euphemistic terms in some liberal democracies, higher education policy in South Africa is more explicit. It is acknowledged and accepted that the higher education system in South Africa is being "steered" through three mechanisms, that is, quality assurance, planning and funding, in order to transform the higher education landscape. Neave (1998) speaks of an "evaluative state" and suggests that this allows governments to steer higher education using a form of remote control. Quality assurance thus becomes an instrument of the state to move higher education in a pre-determined direction that may not be entirely consistent or aligned with the directions of the individual institutions and their stakeholders.

What then is *quality*? There is no definitive answer and in many instances an approach to quality assurance is articulated without getting to the nub of what is meant by the word *quality*. Furthermore, without a clear understanding of what constitutes *quality*, the development and implementation of quality assurance systems are easily challenged. Yet it is a word frequently used by academics and politicians.

There are a multiplicity of conceptual approaches to quality with *fitness for purpose*, *fitness of purpose*, *value for money* and *transformation* being most commonly appropriated by external quality assurance agencies. A practical approach to defining quality is expressed by Ball (1991), who describes *qualities* rather than a finite approach to the definition of *quality*. Ball maintains that "a diversity of functions requires a variety of qualities" and since "higher education has a diversity of functions it must start to recognise a variety of qualities: not *quality* but *qualities*." He further proposes a higher education model (adapted in Figure 3) for the discussion of *quality* and the implications thereof for evaluation. The model focuses on the multiple purposes of higher education, which consequently require a variety of types of evaluations by a variety of "judges". He goes on to explain that the evaluations:

"*will provide a range of indicators with multiple uses. When the uses are understood, one returns to the definition of qualities. It is a continuous cycle.*" (Ball, 1991, p. 102)

Figure 3: A model for qualities of universities of technology (adapted from Ball, 1991)



The application of this model requires that there is a clear understanding of the purposes of the UoTs and that these purposes require the development of specific indicators for specific uses. The identified purpose and relevant performance indicators will thus inform the type of internal and external evaluation that is subsequently undertaken. The outcomes of the evaluation will in turn have implications for the defined purpose, which may be adapted or nuanced accordingly.

This approach to defining quality is aligned with the sentiments expressed by Harvey and Green (1993) as the model makes provision for different perspectives. Furthermore, the approach favours systems thinking which Houston (2008) maintains is a "key precept of quality thinking". Houston goes on to explain that an organisation may be viewed as a "system of systems" and that:

"*A system transforms inputs from the environment into outputs to the environment. For social systems the inputs include*

> *political, economic and cultural norms and expectations … the interactions of these systems and the boundaries placed around the organisation contribute to the particular, arguably unique, emergent properties that define the organisation … all universities are not the same: each university has particular characteristics and boundaries that make it unique … The systems concepts of purpose, boundaries and emergence are particularly helpful in understanding the complex nature of the quality 'mess' in higher education.*" (Houston, 2008, p. 68)

While the development of sector specific performance indicators may be perceived to be important for the UoTs, serious consideration must be given to how these indicators will be used, by whom, and for what purpose. Without clearly and unequivocally stating the purposes of these indicators, the dangers to the sector cannot be ignored. In this regard Tavenas (2003) states that:

> "*The selection of performance indicators is a political and strategic exercise for the institutions concerned. It has to be carried out with due regard for clearly defined institutional objectives. Selection also has to be discriminatory depending on the aims pursued or the particular audience concerned … it is appropriate to combine the analysis of indicators with a more strategic form of analysis that takes account of institutional development priorities.*" (Tavenas, 2003, p. 34)

In view of the inherent challenges with using single performance indicators to describe an activity fully, Tavenas advocates the necessity, firstly, to identify the specific purposes to be evaluated and, secondly, to develop clusters of indicators for each purpose. He elucidates, for example, the following four purposes: internal institutional management; relations with the regulatory authorities; relations with the general public; and international comparisons.

The notion of clusters of performance indicators related to a specific

purpose resonates with the idea of "qualities", the multiplicity of purposes of higher education (Ball, 1991) and reflects the complexity of defining quality underscored in the comment by Houston (2008) about the "quality 'mess' in higher education". There is, therefore, no single definition of quality that can be applied across the UoT sector. While they share a common history in terms of external regulation, each UoT has evolved in a unique way, with a unique context that shapes and nuances quality accordingly. Therefore the UoTs must guard against imposing a simplistic and uniform definition of quality that leaves them open to the dangers of ranking which may be viewed as being another form of external regulation.

Conclusion

The historical development of the UoTs has endowed them with a rich legacy of experience in collaborative partnerships with a range of stakeholders. It is important that these partnerships are nurtured as communities of practice to signal a shift in ethos and one that is aligned with democratic participation.

The collective past experience of the UoTs with regard to external regulation has fostered a willingness to accept the new landscape for quality assurance in higher education. In moving forward it is apparent that since quality should be defined within the context of each individual UoT, the attendant implications for quality assurance must be nuanced accordingly. Therefore, the UoT sector should ensure that these quality assurance systems are robust and promote the confidence of public and private stakeholders in the qualifications of graduates from such universities.

> In drawing on these strengths, the universities of technology affirm that they are not here by accident; rather they are a "product of history, culture, and public and private demand" (Johnstone, 1999).

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Assessing the unique contribution and development of universities of technology (UoTs) through the use of performance indicators

Prof. Engela van Staden

Abstract

The universities of technology (UoTs) that came into existence on 1 January 2004 are functioning in an ever-changing higher education environment for almost six years now due to the implementation of various legislative policies. One of these legislative changes is the promulgation of technikons to universities of technology. It is evident that this sector has not opted for a name change but for an equal status in the new differentiated but unitary higher education system as stipulated in the White Paper 3. Through collegial cooperation, the UoT Sector has conceptualised and contextualised its role and function as one of the three institutional types in the restructured higher education landscape of South Africa. It is very clear that the UoT concept and the nature of its typology are not well known and recognised in South Africa.

It is therefore imperative to advance the unique contribution of UoTs in terms of the human resource development needs of South Africa. For this purpose, the sector has developed performance indicators (PIs), aligned to its role and function, that can measure the performance of this sector and benchmark individual UoTs nationally as well as internationally.

This paper will thus portray the characteristics and criteria that the sector has identified and indicate how it is proposing to assess the unique contribution and development of UoTs in the new differentiated but unitary higher education system and how this sector responds to the demands of South Africa.

Introduction

In 2006, Reddy stated “that since the advent of the new democratic government in 1994, the South African Higher Education System has undergone profound changes”. One of these changes is the promulgation of a technikon to a university of technology in 2003. Since then, various policies have been published which guide the higher education transformation agenda. The latest introduction of such legislation is the following: the National Qualifications Framework Act, 17 February 2009; the Skills Development Act of 1 December 2008; the Higher Education Amendment Act of 27 November 2008; the General and Further Education and Training Quality Assurance Amendment Act, 2008; and the Government Notice of October 2007 on the Higher Education Qualifications Framework (HEQF).

Since the announcement in October 2003, when technikons were proclaimed as universities of technology, a debate originated, stressing the narrowing of the binary divide between the three institutional types in a unitary but supposedly differentiated higher education system as all three kinds of institutions are now funded and managed similarly and all enjoy the same degree of autonomy and academic freedom

(Reddy, 2006). Even the annual performance of all Higher Education Institutions (HEI) is monitored relative to the Minister's published input and output targets through which the levels of institutional government funding is being determined.

Reddy (2006) also argued that the Minister made no clear distinction between universities of technology and the traditional universities. Furthermore, the Minister has not furnished any set of cogent or rational reasons for his decision and the absence of a formulated policy on the differentiation of the single coordinated system of South Africa's Higher Education gave rise to comments such as: "These (technikons) are nothing more than glorified high schools" (Jansen, 2004), which indicated that there is a perceived difference even if it is only from a quality perspective.

As this sector is redefining its focus – to align it with the demands of a developing South Africa and with its university status – it is clear that the development towards recognition as a university of technology is an evolutionary process and that the differentiation debate is pre-mature (SATN, 2007). The UoTs are now witness to policies and directives that appear to introduce differentiation in higher education while the general dimensions for a possible differentiation were already announced in the White Paper 3 (DoE, 1997), namely, planning, funding and quality.

For these reasons, the UoT sector has spearheaded a sectorial project that revisited the "*Position, Role and Function of Universities of Technology in South Africa" (*report released by the Committee of Technikon Principals, 2004) in an attempt to advocate the characteristics, attributes and criteria of a UoT in the South African context and to point out the indicators through which the performance of this sector can be measured.

It became clear that within a unitary system, three university types emerged where "university" is the common denominator and of which the core functions, namely, teaching/learning, research and community engagement are similar. The differentiation is imbedded in the purpose and focus of each university type.

Background

> "*The universities of technology are excited at the prospects in redefining the sector's focus in line with the challenges and demands of a dynamic and developing South Africa positioned within the global market economy. These institutions are determined to continue making significant and infallible contributions towards the sustainable development of our ten-year-old democracy.*" (CTP Press release, 1 March 2004)

With this statement the then Committee of Technikon Principals acknowledged that this sector is new, that it will be redefining its focus, and that it did have and still has a "significant" and "infallible" contribution to make. This was a clear indication that this newly established sector was not opting for a name change, but is inherently dedicated to its unique contribution as a university to the sustainable development in South Africa.

It has been stated by Bitzer (2006) that universities as institutions are not static, and although universal characteristics might be common to all universities, they are organic entities mainly shaped by trends, challenges and forces in their environments. In this context Lategan (2008) contends that universities are known for their three core functions which represent the common characteristics: teaching/learning, research and service as contemplated internationally and supported by the Higher Education Act (No 101 of 1997 amended). Therefore, within the South African context, the three university types, namely, classical universities, comprehensive universities and the universities of technology, have *the idea of the university* as common denominator and these three core functions should be found in *a university* regardless of the university type. Lategan (2008) further argues that the differences between the types of university exist on a conceptual level and therefore also in their approach. Therefore, the difference between university types exists not as a definition but as a concept.

If a university is seen as "an academic institution at which research is conducted and teaching and learning is offered within the organised cadre of the contact between lecturer and student, and supported by networking, cooperation and collaboration with external academic partners to create, develop and transmit new knowledge" (Lategan, 2005), then it is not the use of technology within a university that classifies it as a technological university, but rather the interweaving, focus and interrelation between technology and the nature of the university that constitutes a technological university.

At a technological university the focus is therefore on the study of technology from the viewpoint of various fields of study, rather than on a particular field of study. According to Reddy (2006), a technique, and thus a technology, which is no more than an assemblage of techniques, is not valued for its own sake but for the sake of some end to be achieved by applying it; accordingly, a technical institute cannot emulate a university. However, according to Schuurman (1995; cited in Lategan, 2008), the concept "technology" finds its origin in the Greek word *techne,* which means "skill" or "proficiency" and is also related to the words *episteme*, meaning "understanding and skill", and *poeisis*, which denotes "working, creating," and also "skills". Technology has therefore to do, firstly, with the skill to fabricate things (this includes creating and developing new technologies) and, secondly, the skill to manage the fabricated products. Therefore, technology refers to the *effective and efficient application of the accumulated know-how, knowledge, skills and expertise that, when applied, will result in the output of value-added products, processes and services*. Teaching technology implies, then, an understanding of the application of the subject in the real world but it is also important in a technological university to make technology productive towards commercialisation.

The role of universities of technology as a newly established institutional type needs to be recognised and its status be seen on the same level as other institutional types that have been in existence for a very long time. All higher education institutions are of equal importance but with a different purpose and approach.

University of technology typology

"Typology" refers to the study or systematic classification of types (Encarta Dictionary: English U.K). Similarly, "type" means a brand, kind, mode, a category or class. The distinctive character of UoTs lies *in the way in which the typical university functions of teaching/ learning, research and community engagement are performed* where technology (as per definition) is seen as the qualifier in all three functions (SATN, 2008a). This informed the typology of the UoTs as an academic institution.

A research-based project, managed by the South African Technology Network (SATN), has provided a platform for the typology of universities of technology. The purpose of this project was to indicate the unique contributions of UoTs as a sub-sector in a differentiated higher education system; develop a set of evidence-based performance indicators acceptable to the sector; and document the sector's developmental trajectory. The UoT Sector has through collegial cooperation and collaboration conceptualised and contextualised the role and function of this sector in the new restructured landscape. Engagement with relevant role players such as the Department of Education (DoE), the Council of Higher Education (CHE), Finnish UoTs and representatives of South African UoTs on these documents and their implications has taken place on systemic, sectorial and institutional levels (SATN, 2008a).

Unique contribution of UoTs

The result of the typology was a defined framework of *characteristics, attributes and criteria* for UoTs (see Figure 1). That some of these characteristics and attributes are not unique to the UoT sector or to the South African context is illustrated by references to the United Kingdom, Finland, Germany and the United States made in the final report of the project. These characteristics, attributes and criteria for UoTs have been researched and described in preparation for the development of performance indicators (PIs) (SATN, 2008a).

The UoTs have indicated that undergraduate career-oriented technology-driven programmes (with advisory boards); technological competence; learning in the workplace; applied and multidisciplinary research in strategic areas; partnerships with business, government and industry; student entrepreneurship; SET enrolments; and access with success are the more prominent attributes distinguishing UoTs from other institutions (SATN, 2008a).

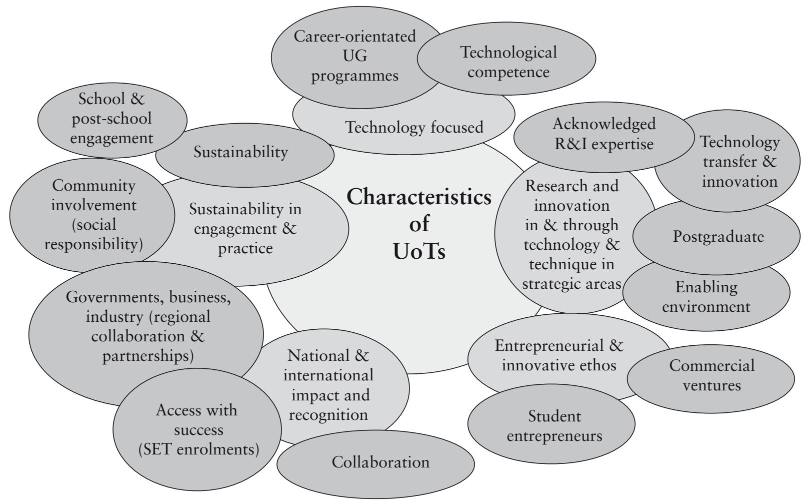
The strategic focus of the UoTs is manifested through its curriculum alignment with the labour market needs and human resource development challenges as indicated in national initiatives and therefore UoTs are primarily concerned with professional and career-focused education on an undergraduate level, focusing on increasing technological capabilities. The curriculum is therefore developed around the graduate profile defined collaboratively with industry and the professions and designed to react responsively to policy directives. The contribution of UoTs to research – understood as the development of a new understanding of a problem through the application of new and/or existing knowledge to a problem – should be recognised. The application of research is thus technology-informed and directs calls for the management thereof. The management of technology as research focus is as important as research directed at applied problem-solving. UoTs are known for their close relationships with commerce and industry, and the work-integrated-learning model (WIL) makes this relationship almost compulsory (SATN, 2008a).

Characteristics of UoTs

It is clear that the nature, role and impact of universities of technology have not been advocated sufficiently to be taken seriously. Therefore the following five characteristics have been identified by the UoT task team, namely:

- **Technology focused programmes**, with attributes such as undergraduate career-oriented education and technological competence;
- **Research and innovation** in and through technology and technique in strategic areas, with the attributes of research expertise, technology transfer and postgraduate programmes;
- **Entrepreneurial and innovative ethos**, with attributes such as the creation of an enabling environment, commercial ventures and student entrepreneurship;
- **National and international impact and recognition**, with service to the community, industry and society, SET-enrolments and access with success as attributes; and
- **Sustainability in engagement and practice**, focusing on regional collaboration, community involvement, engagement with industry and businesses, school/post-school engagement and financial sustainability.

Figure 1: Framework of characteristics and attributes for universities of technology



Aligning the typology to the UoT-specific performance indicators

The performance of all higher education institutions (HEI), relative to the Minister's published input and output targets, is monitored on an annual basis by the Department of Education (DoE). The input and output targets as performance indicators, approved by the Minister for 2010, determine for each public HEI the levels of government funding that the institution will receive for at least a five-year cycle.

Performance indicators

Various performance indicators (PIs) for HEIs have been developed and have been used for various purposes such as measuring the progress towards the national restructuring agenda within the higher education sector, effectiveness, sustainability and/or equity.

Performance Indicators can also be used to measure inevitable outcomes of changes in the system or sector towards improvements. However, reaching consensus on performance indicators has proved particularly difficult. Various studies have provided insight into the difficulty of formulating and using performance indicators in the higher education environment.

The National Working Group (NWG) with its main purpose *"to investigate and advise the Minister on appropriate arrangements for consolidating the provision of Higher Education…"* has identified three properties as a basis for a set of 12 performance indicators (PIs) and benchmarks, namely, equity, sustainability and productivity (DoE, 2001b). These were derived from the policy-driven goals for the system as stipulated in the National Plan for Higher Education (NPHE) (DoE, 2001a).

During a seminar in November 2007 which was sponsored by HESA, ITS and CHET, a proposal was made to measure institutional performance within a peer grouping in order to improve governance. This notion of peer groups is one that is already in use within several higher education systems internationally and is based on institutional size, budget, source of control and outputs. It was clear that a number of institutions had recognised the need to establish benchmarks against which to measure their performance. The choice of peers may vary according to the focus or characteristics of such institutions (HESA, ITS & CHET, 2007).

Other initiatives that contributed to the national debate on identifying appropriate performance indicators are the identification of indicators for a "well-functioning" Higher Education Institution (CHET, 2003), developing PI for higher education (Bunting and Cloete, 2004) and identifying efficiency indicators (File, 2007).

It is clear that the sequence of PI development in South Africa reflected a political and economic trajectory imbedded with issues of equity, quality, governance and efficiency. One of the complications here is that performance indicators are subjected to change if the political environment changes. Another complication is that all HEIs are measured against the same norms and indicators for funding, while the three types of universities in South Africa are equal but different in development and focus.

As the focus of the universities of technology (UoTs) is different and they only came into existence on 1 January 2004, it is possible to monitor and asses the specific role and contribution of this sector through specific, nominated performance indicators. It is also possible to monitor the transformation of the old technikons into fully fledged universities of technology.

For this purpose the UoT sector developed evidence-based performance indicators aligned to a pre-determined framework of characteristics, attributes and criteria that will enable the sector to monitor its development process as well as the performance of all UoTs in the national higher education landscape.

UoT-specific performance indicators

Not all the characteristics and nominated attributes holistically differentiate UoTs from other institutional types but do provide differentiation and uniqueness to some extent as teaching, research and community engagement are common to all university types. There is a general perception that since UoTs now have "university status", little differentiation should exist in the functions of teaching/learning, research/innovation and community engagement. However, differentiation is based on the approach and nature of the institution as defined through the characteristics of the UoTs.

Technology-focused programmes

The technology focused programmes of UoTs are seen as the differentiator with undergraduate career-oriented education and technological competence as attributes. This characteristic does succeed in making UoTs explicitly unique.

The relevancy of the UoTs' technology-focused programme and qualification mix is determined through the curriculum that is developed around the graduate profile defined by industry/professions that improves the market relatedness of the programme (Table 1, page 177). The involvement of professional bodies, advisory committees and appointing experts acknowledged by industry ensures that the programmes respond to the needs of industry, business and society and are therefore providing "just in time" education. Integrating the world at work with learning ensures that the UoTs can produce a student that could start work upon graduation, but UoTs are not only developing job seekers but also entrepreneurs and job creators. Concerned primarily with the development of career/professional education, the curriculum must provide opportunities for the development of technological competencies and capabilities, which are seen as equally important as cognitive skills. Utilising technology within the teaching methodology, including information technology

competencies in the curriculum and integrating e-learning into the teaching and learning experience are some of the criteria that will ensure that UoTs lead in and through technology. This places pressure on UoT staff to stay abreast of technological developments.

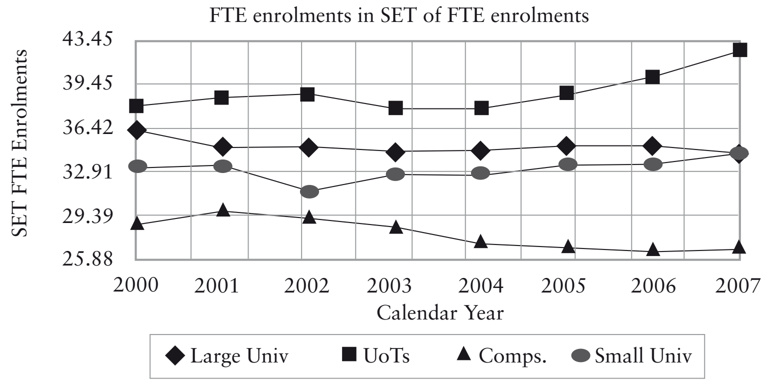
Performance indicators

As stated above, not all nominated attributes of UoTs are unique. However, the following performance indicators are proposed to measure these *unique* attributes of UoTs:

- Percentage FTE enrolments for Science Engineering and Technology (SET);
- Percentage of undergraduate qualifications;
- Ratio of new undergraduate to postgraduate programmes;
- Percentage of programmes with active advisory boards/committees;
- Percentage of undergraduate qualifications that contain learning in the workplace; and
- Percentage of instructional/research staff who have a minimum of 3 years' industry experience.

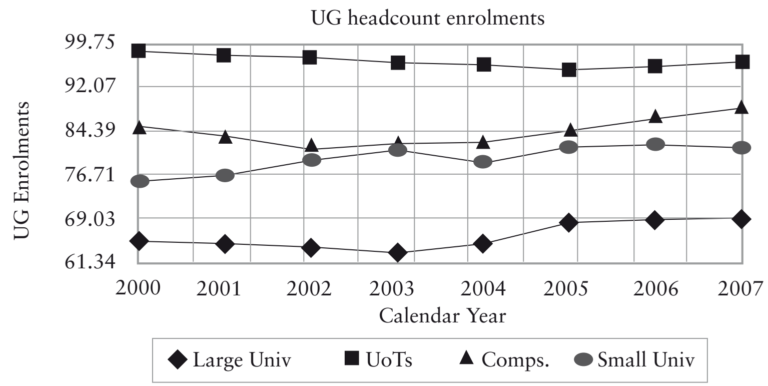
An indication of the unique role that UoTs play regarding the enrolments in SET and programmes in South Africa can be demonstrated in the following graphs. It is statistically proven that UoTs are the largest contributor to the development of learners in the science, engineering and technology fields and that percentage is growing.

Graph 1: Comparison of the SET enrolment shape in South African higher education institutions
Source: HEDA, www.SATN.co.za



The contribution of UoTs to undergraduate level is clearly demonstrated in Graph 2 below.

Graph 2: Comparison of undergraduate enrolment in South African higher education institutions
Source: HEDA, www.SATN.co.za



The following PIs are *generic* to all universities but do inform the shape and nature of the university type. These generic PIs relate specifically to the technology-focused programmes. Targets and benchmarks will provide a platform for differentiation on systemic as well as institutional levels:

- Percentage of qualifications revised;
- Percentage of students employed;
- Percentage of employer satisfaction;
- Ratio of staff development interventions to technological advances;
- Percentage of instructional/research staff affiliated to professional bodies/associations;
- Ratio of FTE students to computer work stations;
- Percentage of curriculum requiring ICT/technology competency;
- Percentage expenditure on ICT/technology in support of T&L;
- Percentage of expenditure on continuous professional development and skills training; and
- Ratio of FTE permanent instructional staff to FTE students.

The technology-focused programmes are the core business of UoTs and therefore none of these attributes is seen as *developmental*.

Table 1 portrays the complete set of performance indicators as developed by the UoT task team and reported to the SATN board (SATN, 2008a).

Table 1: Performance indicators for technology-focused programmes

Attributes	Criteria	Performance indicators
• Undergraduate career programmes	• Technology driven PQM • Professional bodies' approval	1 Percentage headcount/FTE distribution per major fields of study. 2 Percentage of undergraduate qualifications approved/ accredited by professional bodies (where applicable).

Attributes	Criteria	Performance indicators
	• Employer satisfaction with graduates • Responsiveness (just in time education) • Relevance to market needs • Job readiness • Learning in Workplace & WIL • Learner-centred • Innovative educational approaches • Industry exposure and experience of staff • Staff abreast of new developments in technology	3 Percentage of programmes where activity advisory boards/ committees are involved. 4 Percentage of new undergraduate and postgraduate programmes introduced per year. 5 Percentage of qualifications revised per year. 6 Percentage of students employed (including self-employment) in their field of study within one year after graduation. 7 Percentage of employer satisfaction. 8 Percentage of undergraduate qualifications that contain learning in the workplace. 9 Ratio of FTE students to FTE instructional/research staff. 10 Percentage of staff development interventions to embed innovative teaching approaches. 11 Percentage of full-time instructional/research staff affiliated to professional bodies/ associations. 12 Percentage of instructional/ research staff with at least 3 years' recent industry experience.

Attributes	Criteria	Performance indicators
• Technological competence	• Utilising technology within the teaching methodology, including IT-integration and e-learning • Leading-edge technology • Staff abreast with technology/ technological advances	13 Ratio of FTE students to computer work stations on campuses and in residences. 14 Percentage of curriculum requiring ICT/technological competency from learners. 15 Actual expenditure on technology per FTE student in support of teaching and learning. 16 Percentage of expenditure on CPD and skills training with regard to technological advances, per permanent instructional/ research staff headcount.

Research and innovation through technology and technique in strategic areas

The contribution of UoTs to research, which is generally understood as the development of new knowledge, "is the development of a new understanding of a problem through the application of new and/or existing knowledge to the problem" (SATN, 2008a; Lategan, 2008). As Lategan (2008) indicated through a conceptual analysis, it is the approach of UoTs towards research that differentiates it from the traditional universities. This approach, as observed by Brook (, cited by Lategan, 2008), is that research problems of a university of technology are more informed by problems and challenges in business and industry than they are informed by theory. The research methodology is focused more on solving business and industry problems than on solving theoretical issues. New knowledge is created in the process of problem-solving. Scholarship is defined against the background of how applied knowledge can contribute to knowledge creation.

The paramount characteristic of the nature of UoTs' research and innovation is through technology. Therefore technology should be conceptualised in its broadest sense as referring to "the effective and efficient application of the accumulated know-how, knowledge, skills and expertise, that when applied will result in the output of value added products, processes and services" (SATN, 2008a). This wide interpretation of technology implies that the results of technology activities will be diverse. This also means that UoT graduates should be able to do/make things on the basis of their acquired knowledge.

Summarised from Lategan (2008) it can be concluded that:
- Research at a UoT is technology-informed and directed;
- The application of knowledge to an identified problem as technological knowledge is a valid form of knowledge and UoTs are directed at developing this knowledge basis;
- In addressing a particular problem more than a single disciplinary approach is required, which is why research at UoTs is multidisciplinary in nature;
- The application of technological knowledge to a given problem cannot be limited to business and industry only as application to societal problems supersedes the business and industry context by far;
- Research at UoTs has been extended to include activities such as technology transfer, which are interwoven with the academic process; and
- Applied research and the management thereof is as important a focus as research directed at applied problem-solving.

Given this position of UoT research, it can be stated that research in this sub-sector of HE straddles three issues (Lategan, 2008; SATN, 2008a):
- The application of knowledge to address business and industry-related problems (in the broadest sense meaning all sectors in society);
- The training of high-level technologists; and

- The inclusion of a multidisciplinary focus in research.

Research at UoTs is arranged according to, and focused on, niche areas that are enriched by industrial, business and societal experience and partnership in an attempt to address the particular industry needs, as well as building a critical mass of researchers. These initiatives have already resulted in internationally competitive achievements comparable to any other higher education institutions nationally and internationally (SATN, 2008b).

It is then important for UoTs to build the research and innovation expertise of this sector by appointing nationally rated researchers and innovators, staff with doctorates, R&I leaders and research chairs. UoTs also need to extend the research mandate to include activities such as technology transfer, inter- and trans-disciplinary projects, new inventions, fostering partnerships with business and industry and specialising in the application of knowledge. For these purposes, UoTs need to build capacity in strategic postgraduate enrolments.

Performance indicators

It is clear from the above that the nominated attributes of UoTs relating to research and innovation is not unique to UoTs and that the differences in research between the types of universities are very general and that it is the approach of UoTs towards research that differentiate them from the traditional universities.

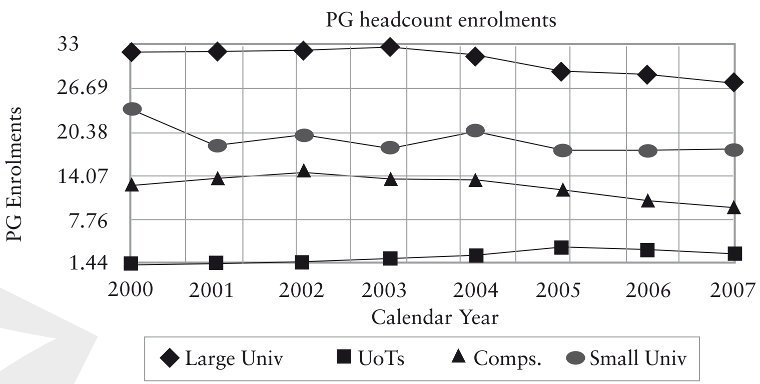
The following performance indicator is proposed to measure the *unique* contribution of UoTs as it is focused on solving particular societal problems in communities:
- Number of community problem-solving research projects.

As UoTs are new to the research arena, the following PIs are proposed to measure the *developmental* nature of UoTs towards their research mandate (see the Report of the Research output committee, SATN 2008b):
- Percentage of staff with a doctoral qualification (minimum of

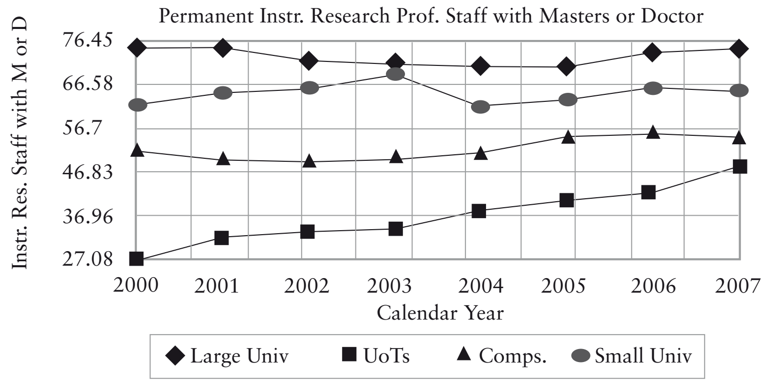
master's qualification);
- Percentage increase of inter-/transdisciplinary R&I project;
- Number of "innovation" outputs;
- Ratio of total research and innovation output, to permanent instructional/research staff;
- Percentage of postgraduate enrolments;
- Ratio of external funding for R&I projects;
- Percentage of postgraduate qualifications awarded; and
- Percentage of postgraduate student participation.

An indication of the role UoTs play regarding the provision of postgraduate students in South Africa as well as the development of its staff towards doctoral qualifications can be demonstrated in Graphs 3 and 4. The current status is a clear indication of the developmental nature of these attributes. It is also statistically clear that UoTs are progressing towards an overall 7% shape.

Graph 3: Comparison of the postgraduate enrolments in South African higher education institutions
Source: HEDA, www.SATN.co.za



Graph 4: Comparison of permanent instructional/ research staff in South African higher education institutions
Source: HEDA, www.SATN.co.za



Attributes that are *generic* among all university types are indicated below. However, the approach whereby research is conducted and applied to a specific problem within a particular industry and business can be categorised as unique to a UoT.
- Number of international collaborations; and
- Number of national collaborations.

The complete set of performance indicators is portrayed in Table 2 (SATN, 2008).

Table 2: Performance indicators for research and innovation in and through technology and technique in strategic areas

Attributes	Criteria	Performance indicators
• Research and innovation expertise	• R&I staff with doctorates • Nationally rated researchers and innovators	1 Number of international collaborations (staff exchanges, research projects, fellowships, joint professorships, cross-instructional projects, research chairs, NRF-rated personnel).

Attributes	Criteria	Performance indicators
	• Internationally recognised R&I leaders • Recent regular R&I outputs • International exchange • Research chairs	2 Number of national collaborations (research projects, fellowships, joint professorships, cross-institutional projects, research chairs). 3 Ratio of total research output to permanent instructional/research staff and full-time permanent staff with a doctorate. 4 Percentage of research income over total income.
• Technology transfer	• Inter- & transdisciplinary R&I projects • New inventions • Partnerships • Specialisation in application	5 Ratio of external funding attracted for R&I projects to total research funding. 6 Percentage of full-time staff with a minimum of a master's qualification. 7 Number of prototypes, patents, processes, artistic outputs and products registered as IP (part of the "innovation" output). 8 Number of completed and sustainable community problem-solving research projects. 9 Percentage increase of inter-/transdisciplinary R&I projects.
• Postgraduate studies	• M & D students in relevant R&I projects	10 Percentage of postgraduate headcount enrolments per total headcount per race and gender. 11 Percentage of postgraduate qualifications awarded. 12 Percentage of postgraduate students participating in contract research.

Entrepreneurship and innovative ethos

The development of student entrepreneurs and instilling an innovative ethos are and should be characteristic of UoTs. It would be misleading to limit innovation to UoTs as the traditional universities have been involved in various downstream activities for a long time. However, the UoT sector sees itself involved in producing innovation outputs in the format of products, prototypes, processes, patents, artefacts, artistic products and designs. It also recognises its involvement in establishing small, medium and macro enterprises (SMMEs)/business ventures in order to diversify the funding base and thus increasing the third stream income (SATN, 2008a). Therefore the first step, as a *developmental* activity, is to provide an enabling environment and seed funding by establishing support and control structures; an enhanced developmental periphery where units such as institutes, centres, technology stations and incubators promote contract research, education and consultancy.

As its mandate the UoTs need to redesign existing curricula to incorporate entrepreneurial competencies, either designed as an exit level outcome or incorporated as a project.

Therefore an entrepreneurial and innovative ethos can be supported by the creation of an enabling environment, commercial ventures and student entrepreneurship, the measuring of which is possible through the performance indicators that assess the developmental nature of this characteristic.

Performance indicators

The following PIs are seen as measuring an attribute that is *unique* to UoTs:

- Percentage of qualifications with entrepreneurship as an exit level outcome.

Attributes of the UoTs that are currently on a *developmental* trajectory, such as business ventures, incubators, technology stations and intellectual property, can be measured as indicated by the

following performance indicators:
• Number of established business ventures;
• Number of SMMEs, incubators and technology stations established; and
• Number of registered IP outputs turned into commercial ventures.

The following PIs are *generic* to all universities but as in the case of the PQM will inform the shape and nature of the university type through specific formulated targets:
• Number of SMMEs supported; and
• Percentage of third stream income from commercial ventures.

The complete set of performance indicators for the entrepreneurial and innovative ethos is portrayed in Table 3 (SATN, 2008). One of the major challenges that UoTs are facing is to obtain and present, from a central system, data that will provide a profile of the UoT sector. There is currently a “Data Sharing Committee” established that is mandated to develop a data sharing system for UoTs.

Table 3: Key performance indicators for entrepreneurial and innovative ethos

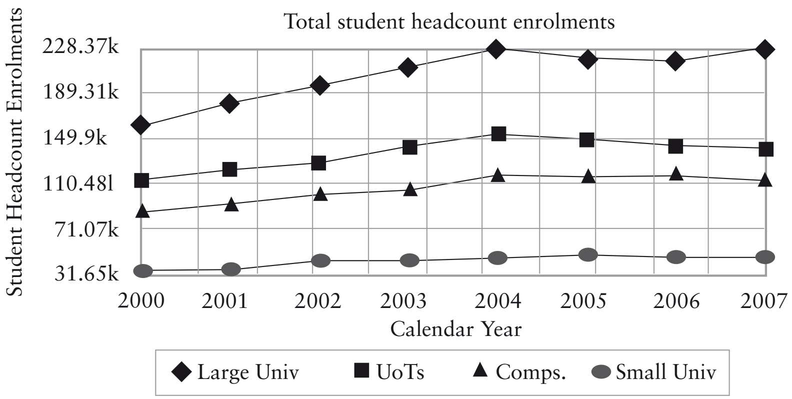
Attributes	Criteria	Performance indicator
• Enabling environment	• Support and control structures • Seed funding/ diversified funding base • Enhanced developmental periphery	1 Number of established business ventures (partnerships, joint ventures and contracts).
• Commercial ventures	• Registered patents and artefacts • Established business ventures, partnerships, contracts • SMME support 3rd stream income	2 Number of SMMEs, incubators and technology stations established. 3 Number of registered PI outputs turned into commercial, (business) ventures divided by the total number of PI outputs (products, prototypes, processes, patents, artefacts and designs). 4 Number of SMMEs supported (count incidences rather than volume). 5 Percentage of third stream income, related to commercial ventures, as part of overall income.
• Student entrepreneurship	• Programmes with entrepreneurship content and projects	6 Percentage of UG qualifications with entrepreneurship as an exit level outcome to the total number of UG qualifications.

National and international impact and recognition

UoTs are seen as institutions that widen access by providing alternative routes of access through foundation provision. Recognition of prior learning (RPL) is also embraced and acknowledges that, in addition to facilitating access, this process is about promoting mobility and progression within education, training and career paths, and accelerating redress of past unfair discrimination in education, training and employment opportunities (SATN, 2008a). Therefore, the growth and the percentage headcount enrolment of first time entering students with a senior certificate, national senior certificate

(NSC) or an FET qualification in relation to other universities will be evident in the access that this sector provides (Graph 5). It is clear from the graph that UoTs are the second largest providers of higher education. The question is: "What is the percentage that UoTs are targeting?" The percentage of students admitted on the basis of RPL or in foundation programmes will be evidence of alternative access routes provided.

Graph 5: Comparison of total headcount enrolment in South African higher education institutions
Source: HEDA, www.SATN.co.za



The overall impact of all higher education institution is measured by the improvement of the success rates of students as stated in the NPHE (DoE, 2001a). The approach of the UoTs is the implementation of various programmes or services in key areas to provide not only access but to ensure access with success. This entails introductory programmes for new students; foundation programmes; programmes which can assist students to become effective in processing and communicating facts; and career counselling services – especially for students who wish to change programmes. At their most basic

level, these programmes deal with language development, numeric development, analytic development, and writing and formulation skills (SATN, 2008).

Performance indicators identified to measure the UoTs' contributions towards national and international impact and recognition can be seen as generic as all University types are compelled to contribute to the improvement of the throughput rate of student cohorts. However, the approach that UoTs follow to effect the improvement is unique.

Another generic performance indicator is the contribution of UoTs to increase the national prioritised skills such as black enrolments in science, engineering and technology. Again, the uniqueness can be related to the target and benchmark that this sector will establish.

The impact and contribution of UoTs on an international level can be measured through the number of international collaborations such as staff and student exchanges, research projects, fellowships, joint professorships, cross-institutional projects, research chairs, keynote addresses, presentations, post-doctorates, and NRF A- or B-rated personnel. This is clearly a developmental trajectory of UoTs that needs additional investment as the mandate of the previous technikon sector was different.

Performance indicators

The following PIs are seen as measuring the attributes that are *unique* to UoTs:

- Percentage of undergraduate students admitted on the basis of RPL; and
- Percentage of undergraduate headcount enrolments in foundation provision.

As indicated above, the attribute of the UoTs that is currently on a *developmental* trajectory is measured as:

- Number of international collaborations.

The following PIs are *generic* to all universities but the target and benchmarks that will be stated by the UoTs will indicate their uniqueness:

- Percentage of South African learners as first time entering students;
- Percentage of females and percentage by race of student headcount per field of specialisation (size and shape/race and gender);
- Percentage of first-time entering undergraduate students who graduate in minimum time plus 1 year;
- Percentage annual growth in student headcount and graduates in national priority areas/fields of specialisation;
- Number of jobs created through SMMEs; and
- Percentage of SADC and other international students.

The complete set of performance indicators is portrayed in Table 4 (SATN, 2008):

Table 4: Key performance indicators for national and international impact and recognition

Attributes	Criteria	Key performance indicator
• National impact (service to the industry, community, society)	• Widening access to HE (alternative routes of access) • Throughput • Nationally prioritised skills and developments • Job creators	1 Percentage of South African learners, with SC/NSC/FET qualifications and enrolled at UoTs as first time entering students. 2 Percentage of undergraduate headcount enrolments in foundation or transition provision. 3 Percentage of females and percentage by race of student headcount per major field of study, namely SET, business & management, education and humanities. 4 Percentage of undergraduate students admitted on the basis of RPL. 5 Percentage of first-time entering undergraduate students who graduate in minimum time plus 1 year. 6 Percentage annual growth in student headcount in national priority areas. 7 Percentage growth in graduates in national priority areas (SET). 8 Number of jobs created through SMMEs.
• International recognition and exposure	• International collaboration (SADC and other international)	9 Percentage of SADC and other international students. 10 Number of international collaborations (staff and student exchanges, research projects, fellowships, joint professorships, cross-institutional projects, research chairs, keynote addresses, presentations, post-doctorates, NRF A- or B-rated personnel.

Sustainability in engagement and practice

"Engagement" means to take the unique characteristics of your institutional type and interact through them (the characteristics) with other entities (SATN, 2008a). As all university types form part of a unitary system and will have a common impact on the human resource development of South Africa, the engagement of each university type will be unique and different. The engagement of UoTs on a national level is evident through their partnerships with, and services rendered to, the industry, businesses, government, communities and society in general. As stated by the UoT sector: "By developing these collaborative partnerships, UoTs not only build their reputation, but also generate additional resources to support the achievement of their goals" (SATN, 2008a). Therefore, the number of regional, national and SADC collaborative partnerships will give an indication of the level and sustainability of UoTs' engagement and embedment on national and regional level. The sustainability can be measured according to the ratio of the income generated from credit-bearing short courses offered as a direct consequence of engagement with these entities. Therefore, UoTs are strengthening their cooperation and partnerships with business and industry in order to be a partner in the emerging knowledge society, as traditional universities have lost their monopoly on knowledge development according to Pratt (2000:49, cited in SATN, 2008a).

Mutually beneficial partnerships for sustainable community development are seen as a *generic* attribute and can be measured by the ratio of community projects to FTE staff. The approach of the UoTs defines them as unique through the applied research problem-solving concept. This will specifically indicate the responsibility and contribution of UoTs to community service without ignoring the role of the other university types to community engagement and service learning.

Engagement with schools and further education and training (FET) institutions is seen as a practice *unique* to UoTs, which enables them to draw upon a greater breadth and depth of potential learners, and therefore not only providing access but also "tapping reservoirs" of human talent that might have been lost. It is possible to measure this kind of engagement through the number of learners from schools participating in co-curricular activities such as vacation or weekend schools; and the number of capacity building programmes that are being offered to FET college staff. The focus of this engagement is the contribution to knowledge and technology transfer.

The last attribute that is the responsibility of all university types, and therefore not unique to UoTs, is to manage the financial sustainability of the institution as part of its public accountability. Measuring the third stream income as a proportion of the total income and determining the ratio of this third stream income to the number of engagements will enable all institutions to determine their financial sustainability. The total direct cost per FTE student and the total income per FTE student are other indicators that are proposed to be used in this regard.

Performance indicators

The *unique* contribution of the UoT sector is evident through its engagement with the post-school sector and can be measured through the following performance indicators:

- Participation rate of FET learners in UoTs; and
- Number of capacity-building programmes offered to FET college staff and other teaching professionals.

None of the attributes proposed are in a developmental stage as partnerships and engagements are necessities to function in the knowledge society.

The following performance indicators are therefore generic to all the university types:

- Number of regional, national and SADC collaborative partnerships;
- Ratio of credit-bearing short courses (CPD programmes) to staff FTEs;
- Ratio of community projects to FTE staff;
- Number of learners from schools participating in co-curricular activities;
- Total direct cost per FTE student;
- Income per FTE student; and
- Ratio of third stream income/total income.

The complete set of performance indicators is portrayed in Table 5 (SATN, 2008).

Table 5: Key performance indicators for sustainability in engagement and practice

Attributes	Criteria	Key performance indicator
• Government, business and industry engagement	• Regional collaboration and embedment	1. Number of regional, national and SADC collaborative partnerships. 2. Ratio of income from credit-bearing short courses offered as direct consequence of government, business and industry engagement to total income generated by short courses.
• Community involvement (social responsibility)	• Mutually beneficial partnerships for sustainable development	3. Ratio of projects (including community and service learning) to FTE staff.
• School and post-school engagement	• Technology and knowledge transfer	4 Number of learners from school participating in co-curricular (vacation/ weekend schools) activities. 5 Number of capacity-building/ upgrading programmes offered to FET college staff and other teaching professionals. 6 Participation rate of FET learners.
• Sustainability	• Financially sustainable	7 Total direct (operational) cost per FTE student. 8 Total income (subsidy/block grants plus tuition fees) per FTE student. 9 Ratio of third stream income to number of engagements. 10 Third stream income as a proportion of total income.

Conclusion

The restructuring of the HE landscape has resulted in a "unitary" system as prescribed by the White Paper 3 (DoE, 1997) and unity was created through the "university" name as common denominator. Therefore the differentiation of these three types is within the approach and focus of the specific institutional type. UoTs have successfully developed a framework of characteristics/attributes and criteria through which its unique contributions and developmental nature are specified and clarified. This sector also made it possible to link its characteristics to the performance indicators through which this uniqueness and development can be measured.

It is also clear that the majority of the attributes proposed for the UoT sector are not unique and are therefore fairly *generic,* which resulted in performance indicators being generic and shared across the HE system. This clearly relates to the "university" concept as the common denominator and its related functions of teaching, research and community engagement.

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Contributing authors

Lesley Anne Cooke
Quality Specialist: Centre for Quality Promotion and Assurance
Durban University of Technology
cookela@dut.ac.za

Prof. Deon de Beer
Dean: Technology Transfer and Innovation
Vaal University of Technology
ddebeer@iclix.co.za

Prof. Roy du Pré
Vice-Chancellor and Principal
Durban University of Technology
dupre@dut.ac.za

Dr Karin Dyason
Director: Research and Innovation
Tshwane University of Technology
dyasonk@tut.ac.za

Associate Prof. Penelope Engel-Hills
Coordinator of Radiography Programmes: Faculty of Health and Wellness
Cape Peninsula University of Technology
engelhillsp@cput.ac.za

Dr James Garaway
Head of Dept: Extended Curriculum, Fundani Centre for Higher Education Development
Cape Peninsula University of Technology
garrawayj@cput.ac.za

Associate Prof. Cecilia Jacobs
Teaching and Learning Coordinator: Faculty of Engineering
Cape Peninsula University of Technology.
jacobsc@cput.ac.za

Dr Bernadette Johnson
Executive Director: Research
Vaal University of Technology
bernadette@vut.ac.za

Prof. Laetus Lategan
Dean: Research and Development
Central University of Technology, Free State
llategan@cut.ac.za

Prof. Alwyn Louw
Deputy Vice-Chancellor: Academic and Research
Vaal University of Technology
alwyn@vut.ac.za

Prof. Sibusiso Moyo
Head of Department: Mathematics, Physics and Statistics
Durban University of Technology
moyos@dut.ac.za

Dr Tembeka Mpako-Ntusi
Director: Research
Cape Peninsula University of Technology
mpako.ntusit@cput.ac.za

Dhaya Naidoo
Director: Quality Promotion
Tshwane University of Technology
naidood@tut.ac.za

Kalawattie Sattar
Director: Centre for Quality Promotion and Assurance
Durban University of Technology
sattark@dut.ac.za

Dr Jan Smit
Director: Curriculum Development
Vaal University of Technology
jans@vut.ac.za

Prof. Engela van Staden
Director: Institutional Planning
Tshwane University of Technology
vanstadenel@tut.ac.za

Associate Prof. Terry Volbrecht
Director: Fundani Centre for Higher Education Development
Cape Peninsula University of Technology
volbrechtt@cput.ac.za

Prof. Christine Winberg
Head of Academic Staff Development, Fundani Centre for Higher Education Development
Cape Peninsula University of Technology
winbergc@cput.ac.za

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