A CONCEPTUAL ANALYSIS OF A UNIVERSITY OF TECHNOLOGY AND ITS CONTRIBUTION TO RESEARCH AND DEVELOPMENT

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ABSTRACT

This paper provides a conceptual overview of one of the three types of university in the South African higher education band, namely the university of technology. The contention of the paper is that universities of technology should have the same core activities as the general or classical university, that is teaching, research and service. The differences between the types of university exist on a conceptual level and therefore also in their approach to science in general. The conceptual analysis illustrates how the university of technology contributes towards research and development. It is for this reason that this university type should be welcomed by the university sector. Its overall contribution to what a university is should be acknowledged.

Key words: university, university of technology, research, research and development, science.

1.   CONCEPTUAL ORIENTATION

Within the context of the South African higher education band, three university types can be identified: classical universities, comprehensive universities and universities of technology. These university types have *the idea of the university* as common denominator. Internationally, universities are known for their three core functions: teaching/learning, research and service. It would therefore be safe to argue that these three core functions should be found in *a university* regardless of the university type. This view is supported by the Higher Education Act (No 101 of 1997, amended) that higher education institutions should be engaged in teaching/learning, research and service. The Size and Shape Report (2000) and the National Plan for Higher Education (2001) support mission and activity differentiation, though not different missions and activities. Where does this leave the core activities of a university of technology? One may answer that the university functions are the same (still teaching/learning, research and service – therefore the functions are *constant*) but that these functions have taken a new direction (for example contract research, commercialisation, innovation, applied research – therefore the *dynamics* of the functions). Dillemans (2006) rightly emphasises the fact that a university exists because of science.

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[1] The research in this paper is based on extensive research into this theme. More extensive overviews can be found in Lategan (1998), Lategan (2000), (Lategan 2005).

This analysis is based on Plato's view of continuity and discontinuity in his youth dialogue *Kratylos.* If *the university* changes (for example by adding new university types), is there still a structural identity to be found in *the university* as a social structure? Is there anything constant in the nature of the university which continues, regardless of any (structural) changes that may occur? Which fundamental structural principle can always be recovered, from the origin of universities, or is each new university and each new period of time purely the product of the organisational creations of humans? Plato realised that all changes can only occur on the basis of constants. No change is possible if there is no foundation for change. With reference to this perspective of Plato, it may be expected that even when the university changes by taking on new forms, the teaching, research and service still have to be continued. Although the university community, for example, may change by introducing new university forms (such as the university of technology), this new adjustment can never be removed from that which is typical of the university. [Kerr (1995) provides an excellent account of how a university can change to fit its context without bidding farewell to its core activities. A good example is how American universities got into military science after the World Wars.]

A fundamental principle in conceptualising a university is therefore that the core activities are both constant and dynamic. *The statement is therefore justified that universities of technology should be engaged in these three core functions but not in the same way as the other (two) university types.*

The conceptual analysis of a university is no stranger to higher education policy studies. The university needs to know itself, and to know what factors are impacting on it (see Teichler 2007). Kerr (1995:7) is even more adamant in this regard: "The university is so many things to so many different people that it must, of necessity, be partially at war with itself." This paper intends to provide an insight into what constitutes a university of technology and how it can make a contribution towards research and development.

2.   BRIEF OVERVIEW OF WHAT A UNIVERSITY OF TECHNOLOGY IS

A university of technology is a unique institution *on par with* the existing general universities. *In literature the difference between these two institutions exists not as a definition but as a concept.* General universities are known for their wide range of disciplines offered through various programmes. Although technology is often used in the programme delivery or as part of the curricula of a programme, technology is not the main *focus of study.* At a university of technology, technology is rather the *object of study* [1].

Brooks (2000) has completed an extensive study on what a university of technology is. From this study it can be concluded that the approaches to science (whether via teaching, research and service) differ. Nowhere does he assign different functions to either of these university types, but rather different approaches to such functions. From the table below it is obvious that universities of technology are more engaged with the needs of business and industry than are general universities.

This by no means implies that the approach of one university type is superior to that of another. It does imply however that each university type has a unique approach to science (see Brook 2000:29).

The table below illustrates the difference between these two university forms:

Table 1: Differentiating a university of technology from a general university

UNIVERSITY OF TECHNOLOGY	GENERAL UNIVERSITY
Research informed	Research driven
Curriculum developed around the graduate profiles defined by industry and professions	Curriculum developed around the academic constructs of the disciplines
Focus on strategic research, applied research into professional practice	Focus on pure or "blue skies" research
Multi-level entry and exit points for students	Focus predominantly on degree and postgraduate level study
Concerned primarily with the development of vocational/professional education	Concerned to some extent with higher education as an end in itself
Technological capabilities as important as cognitive skills	Cognitive skills more important than technological capabilities

Brook (2000:29) rightly observes that the differences are very general and not necessarily exclusive. He also says that in the development of these university types the differences have become more visible. The research problems of a university of technology should be more informed by problems and challenges in business and industry than they are informed by theory. The research methodology should focus more on solving business and industry problems than on solving theoretical issues. New knowledge should be created in the process of problem solving. Scholarship should be defined against the background of how applied knowledge can contribute to knowledge creation. The validity of this approach is not removed from authentic means of scientific developments. Michael Gibbons (1997:21) distinguishes between two modes of knowledge that he calls Mode 1 and Mode 2. Mode 1 is a traditional mode of knowledge production characterised by a linear model. Mode 2 is characterised by knowledge produced in the context of application, transdisciplinarity, heterogeneity and organisational diversity, enhanced social accountability, and broadly based systems of quality control.

Mode 2 knowledge production questions the validity of the linear model of knowledge production characteristic of Mode 1. Mode 2 requires institutions particularly in regard to research, to come to grips with a new pattern for the social distribution of knowledge production, and especially with the fact that they are no longer either the sole or even the primary institutions on the cognitive landscape.

Van Eldik and Fowler (2004) summarise the objectives of a university of technology well in arguing that it promotes institutional diversity. In addition the university of technology may be regarded as a modern option for the serving of higher education needs, business and industry collaboration.

3. THE UNIQUE CHARACTERISTIC OF UNIVERSITY OF TECHNOLOGY RESEARCH

The line of argument thus far is that universities of technology differ from other universities only in respect to their approach to science. Following on this view is the question "How should research be different at the universities of technology?"

Seven directives can answer this question:

First, the original idea of technikon research (from which the universities of technology developed) was to train staff (and further their qualifications) and to provide high-level person power to the industry (via highly skilled technologists). The staff members required for universities of technology are technologists. In return the university of technology staff must train high level technologists for appropriate fields of employment. *The conclusion therefore is that research at the university of technology should be technology-informed and directed.*

Second, 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" (Schuurman 1995:3,4). Technology has therefore to do with the skills to fabricate things. In its broadest sense technology means the ability to do/make something. This means that university of technology graduates should be able to do/make things on the basis of their newly gained knowledge. University of technology research is therefore about the application of (new and/or existing) knowledge to a given problem. The "status" of such a research approach is beyond debate. Applied research is not removed from the principles of basic research. According to the Frascati Manual (OECD 2002) for surveys on research and experimental development, *applied research* refers to original investigation undertaken in order to acquire new knowledge and directed primarily towards specific practical aims or objectives such as determining possible uses for findings of basic research or solving already recognised problems.

Basic research refers to the original investigation with the primary aim of developing more complete knowledge or understanding of the subject under investigation. In view of this one may argue that applied research also makes a contribution to a better understanding of a subject. *Based on this view, the conclusion is that university of technology research deals with the application of knowledge to an identified problem.*

Third, universities of technology specialise in "technological science". Technological science has to do with the development of knowledge and not the collection of knowledge. Schuurman provides a sufficient overview of the development of science and technological science:

Table 2: Technological Sciences

Science	Technology
Existing knowledge ↓	Existing product or process ↓
Via hypothesis and reflection ↓	Via recognition of needs or market research ↓
Hypothesis ↓	New innovation or invention ↓
Via logic and mathematics ↓	Via feasibility study (technological science) ↓
Falsifiable deductions ↓	Adequacy of the design; Testing ↓
Via experiment ↓	Via prototype / development ↓
Confirmation ↓	Production ↓
Via communication ↓	Via public acceptance ↓
New knowledge	New product or process

Technological knowledge is a valid form of knowledge and university of technology research is directed at developing this knowledge basis.

Fourth, a unique factor of university of technology research is its multidisciplinary nature. This approach is not excluded from the new Higher Education Qualification Framework (October 2007). To address a particular problem, more than a single disciplinary approach is required.

This is supported by the fact that technology deals not only with the world of application but also with people applying technology or people affected by the application of technology. Here one could specifically refer to environmental challenges, biotechnology, biomedicine, communication, agriculture, and so forth.

Fifth, the application of technological knowledge to a given problem cannot be limited to business and industry only. Application to societal problems supersedes the business and industry context by far. This explains why universities of technology offer fields of study such as education, government sciences, art, fashion and hospitality management – one could refer to *a partnership model of engagement*. Higher education interacts with four major communities:

• Government
• Industry
• Business
• Social community

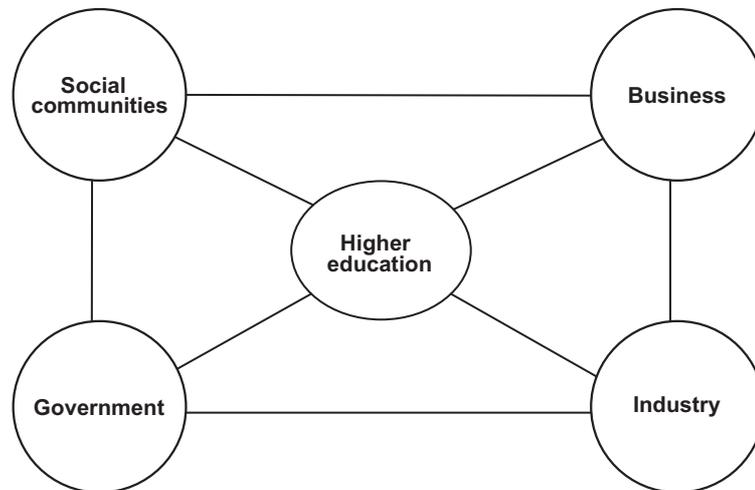This partnership model has opened new opportunities for engagement.

Figure 1: A partnership model of engagement

The knowledge society and its accompanying knowledge creation assignment encourage the university (of technology) to move out of its comfort zone: universities should engage more with the knowledge society and its requirements.

This new requirement does not mean that universities have to take on new functions – rather, they should revise their functions in the context of a changing society. To rephrase - the core functions of a university, that is teaching / learning and research, should be practised in a changing society. The changing society is mainly characterised and dominated by the global economy.

Sixth, research is no longer understood in the context of qualifications, conference papers and journal articles only. The research mandate is extended to include activities such as technology transfer and approaches such as innovation and entrepreneurship (although not unique to a university of technology). These activities and approaches are interwoven with the academic process. Patrick Cunningham, Chief Scientific Advisor to the Irish Government, indicates the positive move between research spin-ins to the university and research spin-outs to business, industry, government and the broader society. He argues that people, money and ideas contribute to research. Research rolls over to publications, citations and patents. Capital investment and startups lead to products and services which contribute towards the benefit of society (Cunningham 2007). The research value chain can best be conceptualised in the following diagram:
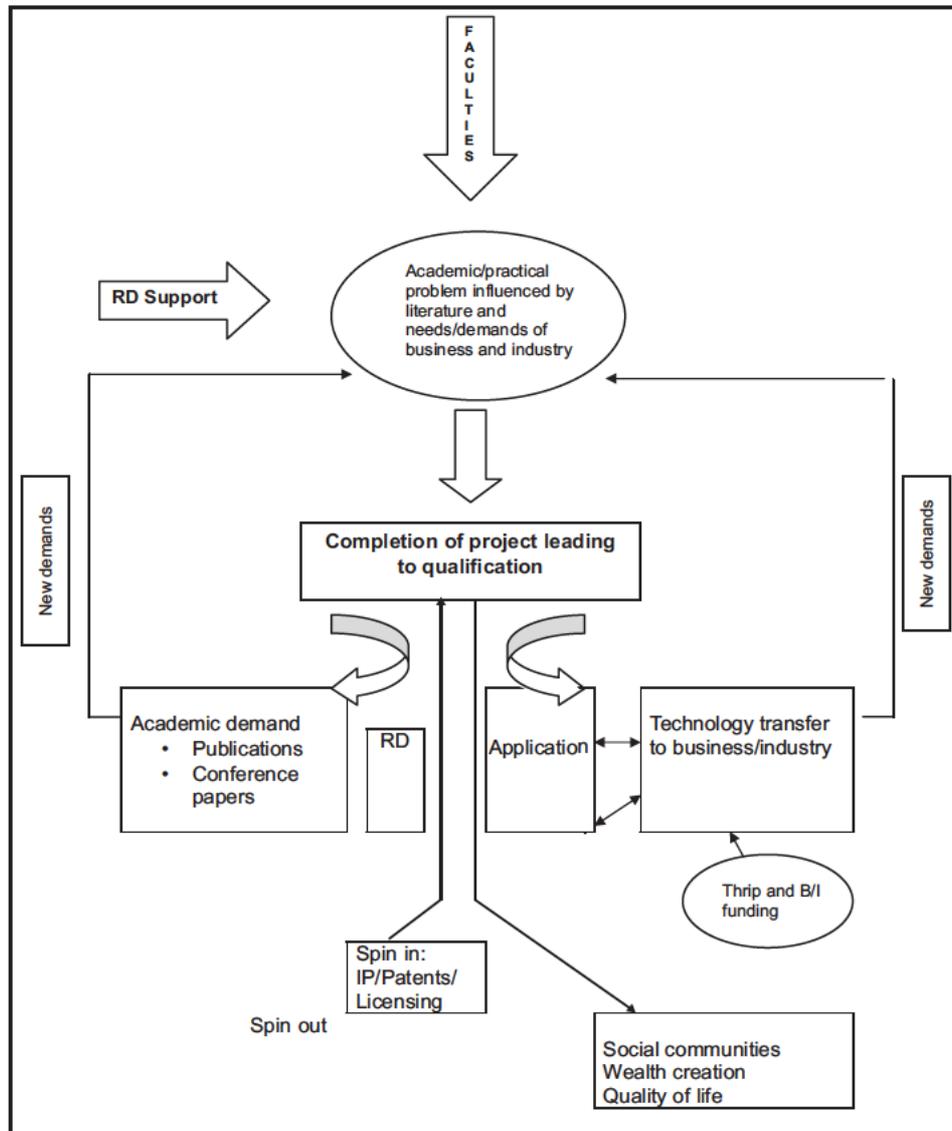
FACULTIES

RD Support

Academic/practical problem influenced by literature and needs/demands of business and industry

New demands

New demands

Completion of project leading to qualification

Academic demand
- Publications
- Conference papers

RD

Application

Technology transfer to business/industry

Thrip and B/I funding

Spin in:
IP/Patents/
Licensing

Spin out

Social communities
Wealth creation
Quality of life

Figure 2: The Research Chain

Seventh, the application of research which is technology-informed and directed calls for the management thereof. The management of technology as research focus is as important as research directed at applied problem solving.

Given this position regarding university of technology research, it may be stated that research in this sub-sector of higher education straddles three issues:

(I)   The application of knowledge to address business and industry (in the broadest sense meaning all sectors in society) related problems.
(ii)   The training of high-level technologists.
(iii)   The inclusion of a multidisciplinary focus in research.

The contribution 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 a problem. Another conclusion follows on this statement: acknowledged outputs cannot be limited to a fixed range of research outputs only. Figure 2 acknowledges the wide range of research outputs that all make a contribution to the system of innovation.

4.   COMMON UNIVERSITY ACTIVITIES SHARED BY UNIVERSITIES OF TECHNOLOGY

It would be a misleading to limit (in a negative sense) research (and) development to universities of technology only and to argue (in a positive sense) that only universities of technology can deal with commercialisation, innovation and entrepreneurship. The fact of the matter is that universities of technology have a responsibility to develop a new generation of researchers working on African and global problems (the principle of brain circulation), to implement new ways of addressing problems (innovation), to create wealth and health (National System of Innovation) – through their (universities of technology) particular focus on research. Through their applied technological research focus, universities of technology can straddle two challenges associated with research in (South) Africa: first, the need to address social problems, and second to be world-class of nature. There is no sense in having a university sector not responding to the society within which it is situated. At the same time the research should make a contribution to global knowledge. Universities of technology can meet both challenges by asking new questions and applying new solutions to problems faced by the (South) African society. An example can be taken from the food research industry. Lues and Lategan (2006) remark on the dual scenario with regard to South African food researchers and technologists: on the one hand there is a vibrant and dynamic milieu where innovative research contributes to novel technologies that give local industry a competitive edge and enable competition on an international front.

On the other hand there is a developing yet lucrative informal food sector where the basic rules of good manufacturing practices still have to be established and where common food contaminants still emerge. These two scenarios are neither in juxtaposition nor can the one ignore what is offered. The university of technology can assist with the development of both by bridging the innovation gap.

This commonality with other university sectors is further articulated through the research objectives (Objective 13 and 14) found in the National Plan for Higher Education (NPHE). In this plan two strategic research objectives are formulated:

•   An increase in the enrolment of postgraduate students.
•   An increase in the research outputs across the spectrum
         of disciplinary enquiry.

It should be noted that these objectives are not reserved for one university type only. Universities of technology can make meaningful contributions to both objectives.

5.   THE CONCEPTUAL PERSPECTIVE IS MORE THAN A
PAPER EXERCISE

The danger of any conceptual analysis is that it can present itself as a paper exercise only. The following example can be observed: The Central University of Technology, Free State (CUT) is aware of its role as a university of technology. Its Research Plan, with its twelve objectives, supports strategic research development. The Research Plan includes initiatives such as increasing the number of research outputs in accredited journals, facilitating the through-put of postgraduate students in the minimum residential period, sustaining and promoting research through public and private funding and promoting regional collaboration. These initiatives are in line with the National Plan for Higher Education (NPHE, 2001).

A special initiative by the CUT to promote and integrate the activities of a university of technology is to develop several strategic research foci to sustain these activities. Research activities should be sustainable and should contribute to the common good of society. This is secured through:

•   A critical mass (staff / students)
•   Third-stream income/grants
•   Reflective practice (outputs and applications)

Sustainability through strategic research programmes that can secure funding is secured, amongst other things, through grants, commercial work, industry- and business-related qualifications, research outputs (qualifications, papers, books, conferences, patents) and commercial work.

This is only possible if there is a critical mass researching a topic of strategic value. The research budget is aligned to support these programmes.

The processes followed to establish the strategic research programmes are:

- Identify strategic programmes
- Benchmarks: number of researchers, students, grants, rating (or futurerating), research outputs, partnerships, co-operation with business and industry, research grants and commercial value
- Process started in June 2005 (discussions via Research Forum, Faculty Research Committees, Central Research Committee, research groups, Academic Planning and Budget Strategy Group and DVC: Academic). First draft presented during NRF visit in October 2005
- Production of information brochure (already three updates)
- Continuous process to accommodate all research activities
- Result: clusters, programmes, niches

Ten strategic research programmes which can be clustered into three research foci were identified. Biotechnology is integrated into many of these programmes and can therefore be regarded as a cross-cutting programme. Benchmarks for a strategic research programme are the number of postgraduate students enrolled and graduated, the number of postdoctoral fellows, the amount of external funding awarded to the programme, as well as the number of active researchers, rated researchers, research publications (books, articles, published conference proceedings and reports) and the amount of commercial work undertaken.

Table 3: Strategic research programmes

Research focus	Research programme
Industrial design, communication and development	- New product development and design - Automated material handling and radio frequency identification - Hydro-informatics - Information and Communication Technology
Quality of health and living	- Applied food sciences and biotechnology - Bio-environmental studies - Applied health technology
People and skills development	- Socio-economic development studies - Education - Research development

To illustrate the benchmarking of these strategic research programmes via fund -ing, accredited publications and postgraduate student enrolment are:

Research funding

During 2006 sufficient external and internal grants were awarded for research. These grants supported various levels of research activities and can be summarised as follows (Central University of Technology Annual Research Report 2006:21):

- External grant agencies (such as NRF, MRC, DST and Absa) funding: R 10 890 041 for 37 grant holders.

- Internal research funding awarded: R 2 110 257 for 72 grant holders.

Research publications

During 2006 the CUT produced the greatest number of accredited research outputs in its history. Staff, students, post-doctoral fellows and research assistants published 42 research articles to the value of 34,71 credits. This is an increase of close to 9 credits compared to the 2005 research outputs. What is also notable is that seven students joined the staff and post-doctoral fellows who published during 2006. Another remarkable development is that 15 of these articles were published in ISI accredited journals. This is an indication that more than one third of CUT research outputs were published in internationally accredited journals.

This growth is reflected in the following table and chart (Central University of Technology Annual Research Report 2006:9):

Table 4: Research outputs

Year	Articles	Credits	Researchers
1998	16	9.76	9
1999	16	10.31	12
2000	13	10.5	12
2001	11	9.49	8
2002	23	19.03	18
2003	27	21.37	27
2004	36	26.9	34
2005	36	25.23	36
2006	42	34.71	41
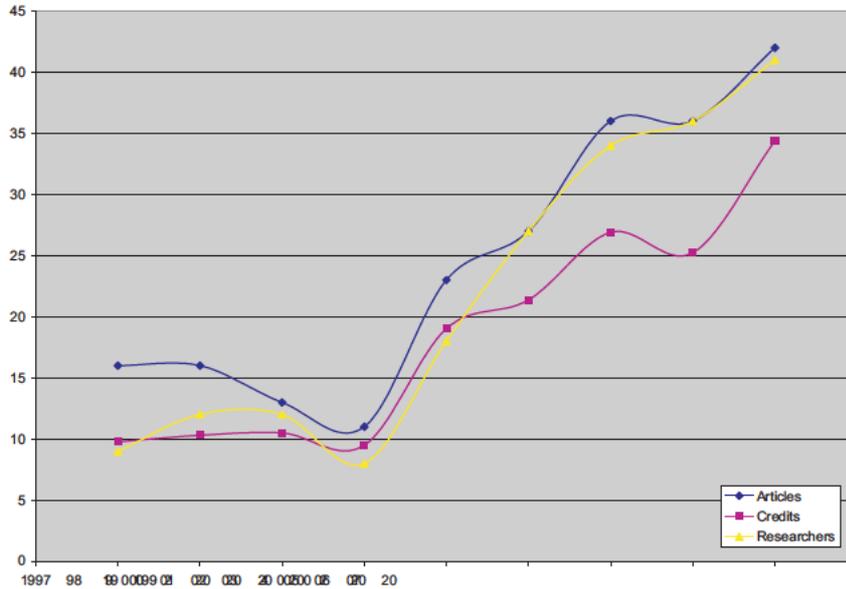
Postgraduate students

During 2006 a total of 10 458 students were enrolled of which 268 were post-graduate students. During 2006 a total of 2319 qualifications were awarded (Central University of Technology Annual Report 2006:5-6).

6.   RESEARCH AS A VALUE DRIVER

Research at universities of technology can take a strategic position through its developmental focus. The development of an applied research focus and a core of high-level technologists demands a sustainable pool of researchers. In the South African context this pool of researchers should be characterised by natural and social scientists (multidisciplinary focus), scientists representative from the broad South African culture (equity), scientists who can function within the context of Mode 2 Knowledge (Gibbons) and scientists that can create a scholarly community (*the* idea of the university). Research development implies the following:

- The training or retraining of young faculty and doctoral students to be in line with global needs.
- The recruitment of new staff.
- The use of international faculties in strategic fields of research.
- The use of talent existing in the private and public sector.
- The establishment of joint ventures between the university of technology and industry (joint research centres and research programmes).

Based on these value-drivers the following managerial objectives may be assigned to universities of technology in their development of research:

Managerial objective 1: Increase the participants in new knowledge development

Contents	To increase the enrolment of postgraduate students (NPHE Objective 13)
Implications	Increase through-put rate of postgraduate students
Benchmarks	What cap should there be – if any – on postgraduate enrolment? Perhaps 10% of total enrolment?

Managerial objective 2: Increase in new knowledge development outputs

Contents	To increase research outputs across the spectrum of disciplinary enquiry (NPHE Objective 14)
Implications	More accredited research outputs
Benchmarks	0.5 credit per full-time staff member annually (credit can consist of publications and completed research Master's and Doctoral studies)

Managerial objective 3: Research as an income generator

Contents	Research will be funded according to outputs categorised as publications, research Master's and Doctoral studies
Implications	Increase in research outputs and joint projects with/for business/industry to enlarge research funds available for equipment, development and incentives for researchers
Benchmarks	Initially 10% of the annual subsidy with a 15% growth rate yearly

Managerial objective 4: Innovation stimulation through research

Contents	Research should create wealth and contribute towards the quality of daily life
Implications	Through innovative research programmes new ideas should be developed that must be (1) commercialised and (2) implemented in the programme mix
Benchmarks	What is the success rate of technology transfer and the incubation of ideas? (the role of Technology Stations and Research Centres)

7.   DIRECTION: THE POSITIONING OF UNIVERSITIES OF TECHNOLOGY WITHIN THE KNOWLEDGE SOCIETY

The emerging knowledge society has tremendous consequences for the university (of technology), regardless its focus of 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 way in which knowledge is being developed.

- Secondly, universities can *sell* their knowledge. In doing so, the 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 for the university of technology to meet these demands, is to direct the teaching and research programmes at meeting *the needs of the society* and also to *identify new possibilities* for the knowledge society's development. The main focus is to create a learning organisation through engagement with business and industry. The university of technology serves 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 is 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, with curricula and research programmes that are theoretical and applied.

This kind of university brings the academic activities into close contact with the needs of the workplace. Academic activities can therefore enrich the world of work. It should be appreciated that universities of technology are becoming more effective in their managerial approaches and interaction with business and industry. Universities of technology should, however, be careful that business principles do not be more important than academic paradigms. To be engaged with your own environment and the environment of the world of work doesn't mean that you have to lose your own unique characteristics and take on features that don't belong to you.   Rather, engagement means to take the unique characteristics of an institution and interact through them (the characteristics) with other life forms. In the process the fundamental principles of the life form are not changed but the way in which the foundations of an institution are practised, is changed.

When a university of technology participates in the knowledge society, it needs to have an innovative approach towards knowledge. The following principles should be taken as points of departure:

•   Increase the percentage of postgraduate students to contribute through their research to the generation of new knowledge.

•   Identify new technology-based fields of study.

•   Redesign existing curricula.

•   Increase the focus on applied research and technology transfer within programmes.

•   Introduce new delivery modes to support the notion of technology-based education and entrepreneurial skills.

8.   CONCLUDING REMARKS

In building a competitive university system in Africa it is important to understand what the African university is[2].   By knowing the system and its strengths it is easier to tell success stories and to foster collaborations (see Harle 2007). The universities in Africa are in a process of aligning themselves and regenerating their potential and impact (see for example the objectives of ICSU Regional Office for Africa).

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[2] In June 2005 a presidential higher education working group remarked that the [South] African universities system bears the stamp of British and other European systems. The question following on this remark would be "What is unique to an African university system?" (Presidential Higher Education Working Document 2005:5). Surely, this is no easy question to answer. Can the university be anything other than an institution engaged with knowledge? I believe that the notion of an African university can have at least three possible interpretations. Firstly, it has a *geographic meaning*: it is a university in a specific location. Secondly, it refers to *institutional systems* in a country/continent in comparison with other systems. Thirdly, it refers to the *institutional character* or *ethos* of an institution

It should be evident from this conceptual analysis that the universities of technology can make a tremendous impact on research and development and therefore on science in Africa.

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