# Building capacity and developing human capital: an exploration of curriculum development in ICT programmes at South African universities

by

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## ABSTRACT

There is a growing consensus on the potential for information and communications technologies (ICTs) to support socio-economic development in sub-Saharan Africa (SSA). Universities as providers of higher education are critical to developing SSA countries by, amongst others,

empowering the region to develop appropriate ICT solutions for local challenges. The purpose of this paper is to describe and discuss how contextual realities influence the development of ICT programme curricula at public universities in South Africa, a developing country in SSA, in order to meet the demand for ICT skills. After a brief discussion of the factors that influence the content and delivery in education systems an overview of the South African public higher education context is provided. Against this background the content and delivery of ICT programme offerings and the rationale behind the programmes at four South African public universities are presented in case study format and concludes with a discussion of the case studies. The paper may be of value to academic departments as examples of how other departments are responding and adjusting their offerings, to government departments and policy makers by engendering a better understanding of the impact of policy on programme development and to industry by illustrating the diverse stakeholders in higher education and academia's responsiveness to these diverse requirements.

**Keywords:**
capacity building, higher education, South Africa, case studies, curriculum development, information and communication technology (ICT), Computer Science, Informatics

## INTRODUCTION

There is a growing consensus on the potential for information and communications technologies (ICTs) to support socio-economic development in sub-Saharan Africa (SSA). Academics, practitioners and governments alike are striving to turn this potential into a reality. Education is of crucial importance in this endeavour since it has intrinsic and instrumental value in creating societies that are better able to respond to the challenges of a more knowledge-intensive economy and is also considered to be central to building the capabilities of individuals and their societies as a whole. Providers of higher education universities in particular are critical to developing a country. They equip individuals with high-level skills for the employment needs of the public and private sectors, they are the dominant producers and critical assessors of new knowledge, they find new local and global applications for existing knowledge, and ultimately provide opportunities for social mobility.

The teaching and learning of ICT skills plays a vital role to empower the region to develop appropriate ICT solutions for the many local challenges in, for example, healthcare. Thus higher education institutions need to increase the number and quality of much needed graduates in ICT-related disciplines. In his research Vesisenaho (2007) verified the importance of local context in ICT education, and in particular that it can lead to more sustainable development and a reduction of the "digital divide." The World Bank's *Task Force on Higher Education and Society* recommends that:

> *each developing country make it [higher education] a national priority to debate and determine what it can realistically expect its higher education system to deliver. The debate must be informed by historical and comparative knowledge about the contribution of higher education to social, economic, and political development - but also should take clear account of the challenges the future will bring* (TFHE 2000:10).

The purpose of this paper is to describe and discuss how contextual realities influence the development of ICT programme curricula at public universities in South Africa, a developing country in SSA, in order to meet the demand for ICT skills for economic and social development in the region. The paper may be of value to academic departments as examples of how other departments are responding and adjusting their offerings, to government departments and policy makers by engendering a better understanding of the impact of policy on programme development and to industry by illustrating the diverse stakeholders in higher education and academia's responsiveness to these diverse requirements. The paper is structured in the following manner: first, a brief discussion on factors that influence the content and delivery of education systems is presented followed by an overview of the South African public higher education context. Thereafter the content and delivery of ICT programme offerings together with the rationale for the development of each at four South African universities are presented in case study format. The paper concludes with a discussion of the case studies.

## INFLUENCES ON CONTENT AND DELIVERY OF EDUCATION SYSTEMS

The educational content and the manner of delivery are captured in a curriculum. Curriculum development may be generically conceived as a combination of the processes used to attain particular goals in an education system. As such curriculum development covers the entire

spectrum ranging from the initial conceptualization and planning to design and implementation to evaluation and revision.

Whilst there is several models for curriculum development it is important to consider the context within which a curriculum is developed because it is a location-specific social construct as outlined above. Education systems are influenced by the political, economic, socio-cultural, technological and regulatory contexts in which they are situated. Educational institutions can be governed either by the state (fully or partially funded by tax-payers) or privately owned either as a non-profit (funded by community organisations) or as a for-profit institution (privately held or with publicly traded shares). The nature of the institution shapes the influences exerted on its curricula; since the focus in this paper is on state-governed public institutions the discussion below uses this as a point of departure.

The policy, strategy, goals and objectives set forth by a government based on the national needs is a key driver of public universities' curriculum decisions. Additionally, legislation and regulations play a key role through the requirement to, for example, harmonise qualifications, recognise prior learning, and, where applicable, meet professional licensing requirements. Accreditation and standardisation also plays an important role. Accreditation is a mechanism for quality assurance in higher education that ensures that a department or programme meets a set of independently specified quality criteria. International accreditation is particularly important for developing countries because it provides an internationally recognised qualification (Calitz *et al*., 2012) that creates an attractive labour force for international investors and corporations and also improves graduates' employment prospects. Incorporating internationally accepted standards into a curriculum is important for similar reasons. Although the merit of including industry certification in an academic programme is contested by some, it offers an attractive combination of internationally recognised certification, access to professional teaching resource materials and targeted marketing possibilities (Koziniec and Dixon, 2002). Model curricula developed by professional bodies are often used as benchmarks to align curricula to other similar programs globally (even when licensing is not required) although there may be competing curricula with significant differences as is the case in the area of computing (Scime and Wania, 2008).

Employer needs, whether in the private or the public sector, plays an important role since, amongst others, the economic motivation is more important than the pursuit of knowledge for

students (Glover *et al.*, 2002). Highly skilled graduates are furthermore important for employers and the economy to compete effectively. Other student-related factors include demographics coupled with their expectations, capabilities and access to enabling infrastructure (for example access to ICTs when developing an online programme). New developments in ICT and new knowledge also impact and require curriculum (re-)development. Institutional factors that impact on curriculum development include, amongst others, the organisational structure and political climate, staff capabilities, capacity and research interests, the available infrastructure, as well as the sustainability of the programme in the future.

## THE SOUTH AFRICAN EDUCATIONAL CONTEXT

In the South African context *higher education* refers to "the education that normally takes place in universities and other education institutions, both public and private, which offer qualifications on the Higher Education Qualifications Framework (HEQF)" as set by the Council on Higher Education (CHE) (DHET, 2012b:1). The HEQF falls within a broader framework, the National Qualifications Framework (NQF) that seeks to harmonise qualifications in South Africa by creating levels from 1 (Grade 9) through 10 (PhD) on which all qualifications are to be placed (DHET, 2012:14).

As a result of apartheid policies prior to 1994 South Africa continues to have a split economy: the so-called first economy is advanced, highly skilled and increasingly globally competitive; the second is mainly informal, unskilled and mostly marginalised. The benefits of the first economy are yet to 'trickle down' to the second economy and without government intervention those in the second economy risk falling further and further behind. Although South Africa's higher education system has transformed dramatically since 1994 the split is still echoed in the higher education sector with leading universities that are internationally respected and historically black universities that continue to face severe financial, human, infrastructural and other resource constraints (DHET, 2012b). Amongst the goals for the transformation of higher education in South Africa is that the education system should produce "graduates with the skills and competencies that build the foundations for lifelong learning, including, critical, analytical, problem-solving and communication skills, as well as the ability to deal with change and diversity" (South African Government, 1997).

Student enrolments have increased dramatically from 1994: enrolments in public higher education rose from 495,356 students in 1994 to 837,120 students in 2010. By 2009, the proportion of black South African students in the overall higher education system had grown to 65% and the proportion of women had risen to 57% (DHET, 2012a:9). Nearly two-thirds of students (62%) are undergoing contact-based study, with the remainder enrolled in distance education (DHET, 2012a). In Science, Engineering and Technology (SET) headcount enrolment has grown by 4.4% annually between 2000 and 2009, and graduation rates in these areas have grown by 5.5% annually (DHET, 2012a). The aim is to raise the participation rate in universities to 23% or approximately 1,5 million students by 2030 from the current rate of 16% (DHET, 2012b:45). In spite of increased enrolment and throughput rates persistent graduate unemployment in the face of skills shortages is seen as an indication that universities are not producing graduates who adequately meet the needs of industry and society (NPC, 2012:317). It may also be that students are not enrolling in programs in scarce skills areas due to perceived difficulty, lack of knowledge of labour market needs, and lack of role models, amongst other reasons.

Apart from the rapid increase in student enrolment, universities themselves have also changed dramatically over the last decade. The restructuring of the university system between 2000 and 2005 resulted in new institutional types. South Africa now has 23 public universities that comprise eleven traditional universities, six universities of technology and six comprehensive universities, which combine the functions of traditional universities and universities of technology. A differentiated system of university education can enable institutions to find niches to enhance their ability to meet national needs, provide a diversity of programme offerings to learners, provide for flexibility and innovation throughout the system and increase the overall participation rates in higher education in South Africa (DHET, 2012:39). The eleven traditional universities offer various academic and professional Bachelor degrees usually 3 years in duration and a small number of diplomas and certificates at the undergraduate level. Postgraduate degrees comprise of honours (a 1-year degree following the three-year Bachelor degree), masters and doctoral degrees as well as a limited number of postgraduate diplomas and certificates. Universities of technology offer a number of vocationally oriented undergraduate diplomas as well as Bachelor of Technology degrees. Postgraduate study at universities of technology is limited to a relatively small number of masters and doctoral programmes. The comprehensive

universities offer a combination of traditional university and university of technology programmes (DHET, 2012b:37).

To address the persistent historical split and encourage greater participation and equality in post-school education the Department of Higher Education and Training (DHET), the department tasked with the post-school education and training in South Africa, released a *Green Paper for Post-School Education and Training* (DHET, 2012b), the contents of which is supported and expanded in the *National Development Plan 2030: Our Future – make it work* (NPC, 2012) published by the National Planning Commission (NPC).

According to the NPC (2012) the education system must play a greater role in building an inclusive society by providing equal opportunities and by helping all South Africans to realise their full potential. In particular, the graduates of South Africa's universities and colleges "should have the skills and knowledge to meet the present and future needs of the economy and society" (NPC, 2012:296) and all universities in South Africa must offer a high-quality undergraduate education as the first step in overcoming historical injustices and as an academic foundations for students who wish to go on to postgraduate studies (DHET, 2012b:40). Undergraduate throughput rates must be improved to increase the skills available to the economy and to provide larger numbers of students available for postgraduate study (DHET, 2012b:42). Universities must further, amongst others:

- *Define their niches to enhance their ability to contribute to national objectives*
- *Provide a diversity of programme offerings to learners (NPC, 2012:318).*

As a result of these requirements, the mix and level of programmes offered at any particular institution should not be fixed, but should be flexible enough to be developed over time to take in more or fewer postgraduate programmes or new disciplines (DHET, 2012b:40). At the same time it is necessary to ensure that students enrolled in similar programmes in different institutions receive a comparable education (NPC, 2012:319) and that students should be able to move between colleges and universities, between different universities, between schools and post-school institutions, and between educational provision and the world of work (NPC, 2012:324).

There should also be "clear linkages between education and training and the world of work" (NPC, 2012:296) although, admittedly, there is "inadequate information about labour market

needs and future growth possibilities, which makes planning and targeting of provision difficult" (DHET, 2012b:14). While partnerships between employers and universities do exist at some educational institutions, they are virtually non-existent at others and there is a serious shortage of places for students to gain workplace experience that severely restricts the development of skills relevant to the economy (DHET, 2012b:14).

In addition to infrastructure expansion at historically disadvantaged institutions, permission for all universities to use ICT to enable distance education that can reach more learners and an option of a four-year undergraduate Bachelor degree that combines bridging courses to help students from disadvantaged backgrounds should lead to increased participation and completion (DHET, 2012b). Greater emphasis on the exploitation of ICT for e-learning and m-learning and a move to open learning using open educational resources (OER) is outlined in the recently released *Draft Policy Framework for the Provision of Distance Education in South African Universities* (DHET, 2012a) although the challenges to enabling this move are also acknowledged, including the development of appropriate high-quality learning resources along with access to and use of appropriate ICT by both institutions and prospective students.

In terms of accreditation there is no professional body specifically accrediting ICT degree programmes in South Africa, although there are a number of professional bodies such as the *Computer Society of South Africa* (CSSA) and *South African Institute of Computer Scientists and Information Technologists* (SAICSIT). Given the lack of a local accrediting body international accreditation of academic programs in Computer Science, Information Systems, Information Technology and other related programs is increasing annually (Calitz *et al.*, 2011).

## CASE STUDIES OF ICT PROGRAMME CURRICULUM DEVELOPMENT IN SOUTH AFRICA

In this section the curriculum development responses of three traditional universities and a comprehensive university with respect to their ICT programme offerings are provided. The case study from the *University of South Africa* outlines the development of new programmes in information technology (IT) service management, the *University of the Western Cape* outlines the revision of an existing programme in Computer Science, the *University of Pretoria* reports and reflects on an interdisciplinary IT programme that was introduced in 2000 and the *North-*

*West University* case describes the School of IT BSc(IT) programmes offered on the university's Vaal Triangle Campus.

**University of South Africa's ITSM programmes in the School of Computing**

The University of South Africa (Unisa) is a comprehensive university dedicated to distance education and its vision is "towards the African University in the service of humanity." Of all South Africa's distance education students, 83% are at the Unisa (DHET, 2012b:37) with a headcount of more than 350,000 students from over 130 countries. The institution offers a diverse choice of study fields, at levels from vocational certificates to academic degrees; it therefore provides learners with industry-focussed opportunities to learn and develop IT management skills.

The School of Computing (SoC) currently has a limited vocational educational choice for its students: Diploma, BTech and MTech with the BTech and MTech to be phased out in future. In addition to the Computer Science (CS) and Information Systems (IS) offerings, the School is expanding its qualification choices to provide vocational opportunities for learners at different levels as is required by the government of a comprehensive university, with progressions from one level to another. The Advanced Diploma qualification in the IT field hopes to prepare students to provide for the skill shortage in the country and provide efficient service focus. This is a somewhat different approach than that suggested by Conger (2009) who believes that IS programmes provide the best home for IT service management (ITSM) content. ITSM aligns the delivery of IT services with needs of the organisation, emphasizing benefits to its users and covers Service Desk, Technical Management & Application Management, IT Operations Management, Ethics, Access Management, Request Fulfillment, Event Management, Incident Management and Problem Management. The SoC chose to develop new programmes, which are the third option along integration of content and the addition of new modules to existing programmes (Jarmin, 2011). Although the development of new ITSM majors are indeed a bit "overwhelming," the School had no choice, because it was forced to replace complete, outdated programmes with new ones, and ITSM emerged as the ideal platform on which to build three new vocational qualifications.

The South African ICT industry, as in most developed and developing countries in the world, provides a strategically important service to the economy across a wide spectrum of industries,

ensuring sustained business performance and efficient business processes and activities. Growing dependency on ICT as a result of the integration of IT and business processes in virtually every industry has emphasised the need to ensure continued availability of supporting ICT systems and functions. Any breakdown or delay in these services represents a significant business risk, often associated with severe economic and reputational loss. Corporate governance requirements, and more specific ICT governance, place the management of ICT and the managing of the risks associated with ICT services, in a category of risk management that has become the responsibility of executives and board members in most organisations. Business's constantly increasing dependencies on sustainable, high availability ICT support systems will continue to increase management focus on the associated risks. This focus will continue to demand pro- as well as re-active management actions to ensure the availability of ICT systems. The increasing dependency on ICT services and support, points to the need for developing more intermediate managers like technicians, operations, supervisory and management personnel in the ICT sector. This will ensure the capability to maintain these services at the required critical operational levels.

There is a severe skills shortage in South Africa at the moment. IT and ITSM are considered scarce skills by the Department of Labour (DoL). It addresses objectives of the NQF by providing a crucial link between the globally recognised Information Technology Infrastructure Library (ITIL) guidelines for ITSM and the underpinning theory. Internationally, there is an increasing awareness that ITSM, as taught by universities, should be drawing from ITIL as a basis. This argument by Jarman (2011), where he indicated that, in general terms, if things are done the ITIL way, then a very high level of ITSM should be achieved. The qualification is beneficial to the economy and society as it addresses some of the training needs for the successful operation of ICT systems in organisations. Skilled ITSM personnel are required to meet the developmental needs of the country in the wider application and use of advanced ICT systems in support of business as well as government and other mission critical operations. This qualification will deliver learners to satisfy the growing need in industry for professionals with both IT and business knowledge. Learners that complete the qualification successfully can pursue a career in ICT Operations Management, Change Management and Control, ICT Asset Management, User Liaison and Account Management, ICT Help Desk Management and ICT Security Management to mention only a few. This has become the trend internationally as well.

The qualification prepares the qualifying student for an ICT support occupation by providing:

- Fundamental knowledge underpinned by a thorough theoretical base that informs the ITSM activity as well as contextual knowledge required.
- Self-management principles such as taking responsibility and applying appropriate judgement, engaging in lifelong learning, acting ethically and working as part of a team.

The SoC has met with several companies that have shown great interest in the ITSM qualification. The aforementioned companies have also expressed a need for an advanced qualification in this field. Furthermore, comments received from a survey conducted on the proposal of the new qualification support the rationale: of 209 respondents in the IT field 87.5% felt that there was a gap with the current IT qualifications available in that most graduates have little idea of ITIL. The inclusion of ITIL in the ITSM will hopefully make these excellent qualifications that are well rounded with practical offerings. After this gap was identified it was decided to develop a qualification to address this need. It is also the first step in providing further postgraduate possibilities.

The Advanced Diploma in ITSM is designed to provide for progression towards a Postgraduate Diploma or an Honours Bachelor's Degree. It is based primarily on the Information Technology Infrastructure Library (ITIL) best practices and policies guidelines and frameworks. A partially taught master's degree will be the highest qualification in the series. The proposed structure of each of the three qualifications is discussed below.

*Advanced Diploma in ITSM*

The Advanced Diploma consists of fundamental ITSM concepts, service management functions and service operation processes and some additional topics (see Table 1).

*Postgraduate Diploma in ITSM*

The Postgraduate Diploma in ITSM is designed to provide for progression towards a Master's degree. The diploma consists of an Inter-mediate overview of ITSM, service design processes and service transition processes and some additional topics (see Table 2).

**Table 1: Modules in the Advanced Diploma in ITSM**

| Module title | Credits | NQF level |
|---|---|---|
| Principle concepts of ITSM | 12 | 7 |
| Service Management Functions (Service Desk) | 12 | 7 |
| Technical Management | 12 | 7 |
| Application Management & IT Operations Management | 12 | 7 |
| IT Ethics | 12 | 7 |
| Service operation processes | 12 | 7 |
| Request Fulfilment | 12 | 7 |
| Research Script | 12 | 7 |
| Event Management | 12 | 7 |
| Incident & Problem Management | 12 | 7 |

**Table 2:Modules in the Postgraduate Diploma in ITSM**

| Module title | Credits | NQF level |
|---|---|---|
| Research Methodology | 24 | 8 |
| Research Report | 24 | 8 |
| Service Design Management | 12 | 8 |
| Service Level & Supplier Management | 12 | 8 |
| Knowledge Management | 12 | 8 |
| Change Management | 12 | 8 |
| Service Catalogue Management & Capacity Management & Availability Management | 12 | 8 |
| Service Validation, Testing & Evaluation | 12 | 8 |

*Masters degree in ITSM*

The Masters in Information Technology in ITSM is designed to provide for progression towards a doctoral degree. The degree consists of advanced overview of ITSM, service strategy processes and continual service improvement and some additional topics (see Table 3).

## University of the Western Cape's revision of the Computer Science curriculum

Situated in Belville in the greater Cape Town the University of the Western Cape (UWC) is a national university that is alert to its African and international context as it strives to be a place of quality and is committed to excellence in teaching, learning and research, to nurturing the cultural diversity of South Africa as well as responsive in critical and creative ways to the needs of a society in transition (UWC, 2009a). A specific goal is "to create and maintain a criticalteaching and learning environment offering undergraduate, professional, and postgraduate programmes of the highest quality" (UWC, 2009b).

**Table 3: Modules in the Masters degree in ITSM**

| Module title | Credits | NQF level |
|---|---|---|
| Advanced Overview of ITSM | 12 | 9 |
| Strategy Generation | 12 | 9 |
| Financial Management & Demand Management | 12 | 9 |
| Service Portfolio Management, Reporting & Service Measurement | 12 | 9 |
| Quality Management | 12 | 9 |
| ICT Project Management | 12 | 9 |
| ICT Risk Management & IT Law | 12 | 9 |
| Enterprise Architecture, Management & Leadership | 12 | 9 |
| Research methods and proposal | 24 | 8 |
| Dissertation | 60 | 9 |

The Department of Computer Science at the UWC offers a Bachelor of Science (BSc) undergraduate degree programme as well as postgraduate degrees at Honours, Masters and PhD level. Both the Masters and PhD are research-based degrees. The main areas of research within the department are artificial intelligence, software engineering, networking, and information communication technology for development (ICT4D).

Programmes offered at UWC are reconsidered and updated annually at a workshop with the aim to keep the curricula relevant and aligned to international standards. In 2012 the Computer Science Curricula 2013 (CS2013) was used as a guideline (ACM/IEEE-CS Joint Task Force on Computing Curricula, 2012). CS2013 is a revision of the computer science curricular guidelines published in 2001 (CC2001) (ACM/IEEE-CS Joint Task Force on Computing Curricula, 2001) and an interim review, CS2008, published in 2008 (ACM/IEEE-CS Joint Interim Task Force, 2008). In the 2013 revision, the knowledge units have been revised as well as what is considered essential for a Computer Science curriculum.

Eighteen so-called knowledge areas have been identified where courses do not have to cover only one knowledge area but could incorporate several knowledge areas. The knowledge areas are further divided into two tiers. Tier 1 is considered a required part of every computer science curriculum for every student, whereas tier 2 is generally considered essential or highly recommended but may not be required (see Table 4). The tiered-approach allows flexibility for institutions to adapt the guidelines as needed.

**Table 4: Hours allocated to each knowledge area (ACM/IEEE-CS Joint Task Force on Computing Curricula, 2012:33)**

| Knowledge Area | CC2001 | CS2008 | CS2013 | |
|---|---|---|---|---|
| | | | Tier 1 | Tier 2 |
| AL-Algorithms & Complexity | 31 | 31 | 19 | 9 |
| AR-Architecture | 36 | 36 | 0 | 16 |
| CN-Computational Science | 0 | 0 | 1 | 0 |
| DS-Discrete Structures | 43 | 43 | 37 | 4 |
| GV-Graphics – and Visual Computing | 3 | 3 | 2 | 1 |
| HC-Human Computer Interaction | 8 | 8 | 4 | 4 |
| IAS-Security and Information Assurance | -- | -- | 2 | 6 |
| IF-Information Management | 10 | 11 | 1 | 9 |
| IS-Intelligent Systems | 10 | 10 | 0 | 10 |
| NC-Networking and Communications | 15 | 15 | 3 | 7 |
| OS-Operating Systems | 18 | 18 | 4 | 11 |
| PD-Parallel and Distributed Computing | -- | -- | 5 | 10 |
| PL-Programming Languages | -- | -- | 8 | 20 |
| SDF-Software Development Fundamentals | 38 | 47 | 42 | 0 |
| SE-Software Engineering | 31 | 31 | 6 | 21 |
| SF-Systems Fundamentals | -- | -- | 18 | 9 |
| SP-Social and Professional Issues | 16 | 16 | 11 | 5 |
| **Total core hours** | **280** | **290** | **163** | **142** |
| **All tier 1 +80% of Tier 2 = 276.6** | | | | |

Currently the department is analysing its courses. Each course is mapped against the content and number of hours required according to the CS2013 guidelines, in order to determine whether these courses should be changed or the time allocation adjusted. Since the Computer Science curricula referred to by the ACM is taught over 4 years, the Honours degree was included in this calculation.

In the Strawman draft (ACM/IEEE-CS Joint Task Force on Computing Curricula. 2001:11) it is mentioned that

> *the education that undergraduates in Computer Science receive must adequately prepare them for the workforce in a more holistic way than simply conveying technical facts. Indeed 'soft skills' (such as teamwork and communication) and personal attributes (such as identification of opportunity and risk) play a critical role in the workplace.*

This was also referred to in a publication that considered graduate attributes of Computer Science students in Sub-Saharan Africa (SSA):

> *... SSA graduates should have skills that will enable them to work for any global information technology (IT) company. Additionally they should be equipped with more specific skills to tackle challenges faced by their communities (Rai et al., 2011).*

To encourage the development of these "softer skills" or graduate attributes, the development of these skills are infused into all the years from the first year to the Masters degree (see Table 5).

**Table 5: Infusion objectives from first year to Masters level**

| **Infusion objectives** | **Description (1=1st Years; 2=2nd Years; 3=3rd Years; 4=Honours; 5=Masters)** |
|---|---|
| Comprehension and communication skills | 1. Comprehend and summarise popular articles (e.g. Time, CNN, newspapers, PC Magazine, Byte, etc.)<br>2. Team oral presentation, written report on their own work, and comprehend and summarise articles (Linux Journal, Dr. Dobbs)<br>3. Individual oral presentation and comprehend and summarise technical articles (IEEE Computer, Communications of the ACM) and online newsgroups.<br>4. Comprehend and criticise research articles (ACM SIG publications and IEEE Transactions, IFIP working groups). Oral presentation on research.<br>5. Co-author and present research articles to conferences |
| Problem solving | 1. Problem comprehension, decomposition and solution of simple problems, algorithm/pseudo code and "divide and conquer".<br>2. Introduction to algorithmic techniques and complexity applied to standard problems.<br>3. Application of algorithmic techniques and complexity to advanced problems.<br>4. Research and apply techniques to solve "real world" problems.<br>5. Independent investigation and solution of a difficult problem. |
| Programming competency | 1. Implement a given algorithm in a high level procedural programming language.<br>2. Able to solve problems with advanced features of a high level programming language. Introduction to a second programming language.<br>3. Able to code robust and efficient solutions using contemporary software development tools. Introduction to a third programming language.<br>4. Proficient in a second programming language. Independently learn and use additional languages. Implement profiling, revision control and libraries.<br>5. Software reuse, intimate knowledge of a programming language, rapid prototyping and ability to choose appropriate software development tools, software maintenance. |
| Team work | 1. Participate in team activities with assigned schedule.<br>2. Schedule team activities with individual contributions to combined task.<br>3. Assume different roles within a team.<br>4. Collaborative team effort toward a significant problem, e.g. Honours project.<br>5. Participate in a research culture: ability to provide resources to other members and be able to identify other members' skills and resources. |

| **Infusion objectives** | **Description (1=1st Years; 2=2nd Years; 3=3rd Years; 4=Honours; 5=Masters)** |
|---|---|
| Leadership | 1. Self-discipline and time management.<br>2. Provide tutoring and/or practical assistance to 1st year students.<br>3. Provide tutoring and/or practical assistance to 1st and 2nd year students and mentor 1st year students.<br>4. Supervise a 2nd or 3rd year team.<br>5. Co-supervision of Honours projects. |
| Ethics and Professionalism | 1. Aware of and comply with Internet ethics, software licenses, and regulations regarding cheating and plagiarism.<br>2. Aware of and comply with local professional body code of ethics, e.g. CSSA, SAICSIT, Professional conduct.<br>3. Obtain student membership in local professional body, e.g. CSSA, SAICSIT.<br>4. Aware and comply with intellectual property laws. Obtain student membership in ACM or IEEE.<br>5. Maintain student membership of ACM and/or IEEE. |
| Responsibility | 1. Adhering to deadlines and taking responsibility for own learning.<br>2. Take initiative for own learning and scheduling/time management.<br>3. Be a role model for the 1st and 2nd years.<br>4. Take responsibility to uphold and promote departmental image. Act as ambassadors to the community.<br>5. Participate in department activities. Be a role model to all undergraduate and Honours students. |
| Software development | 1. Develop basic debugging and code documentation skills. Introduction of life cycle model and object oriented design method<br>2. Understanding and utilization of life cycle models. Apply OO analysis and design methods. Use standard documentation and testing strategies.<br>3. Use CASE tools and software reuse. Exposure to ISO standards.<br>4. Implement project management and software processes and methods.<br>5. Software quality control and assurance. |
| Research methods | 1. Indicate sources of material. Learn search techniques on Internet and library.<br>2. Indicate sources in more detail. Discern credibility and timeliness of resources.<br>3. Independently locate research resources.<br>4. Criticise and appraise research articles.<br>5. Write a research proposal, build and adhere to a project plan to achieve the research goals. Familiarity with research methods and be able to choose an appropriate methodology. |

## University of Pretoria's interdisciplinary IT degree in the School of Information Technology

The University of Pretoria is a teaching and research university that strives to be an internationally competitive, locally relevant, inclusive institution with a focus on academic

excellence and quality. It also aims to be the university of choice for not only students and staff but also for employers of graduates as well as those requiring research solutions.

Situated in the *Faculty of Engineering, Built Environment and Information Technology* the School of Information Technology (SIT) was created in 1998. The School comprises three departments: Computer Science, Informatics and Information Science. Computer Science focuses on computers and computational systems: their theory, design, development, and application. Main areas within computer science include artificial intelligence, computer systems, database systems, programming languages, software engineering, and theory of computing. Informatics (Management Information Systems or MIS) studies the design and application of information systems within organisations. There is consequently a strong focus on the business and organisational side of information systems including analysis and design, database design and implementation and programming. Information Science is concerned with gathering, manipulating, storing, retrieving and classifying recorded information as well as ethical aspects of ICT and focuses on knowledge management, information retrieval and organisation, publishing of printed media, and multimedia programming. The School offers nine conventional undergraduate degree programmes in the three disciplines as well as all postgraduate degrees associated with these undergraduate degrees up to a doctoral level.

Cooperation between the three Departments lead to greater interdisciplinary research and the close collaboration between these departments allowed the School to develop a degree program that combine subjects from the three departments with a view that interdisciplinary preparation of students will be vital for the future. As a result the Masters in Information Technology (MIT) was introduced in 1999 and the Baccalaureus of Information Technology (BIT) in 2000. At the time there were no similar degrees offered in South Africa although there were several such degree programmes offered by Australian universities. As reported by Matthee and De Villiers (2005) when developing the BIT degree the focus was on preparing graduates for the requirement of practice. The assumption was that IT professionals will benefit most from a balanced view of IT combined with sound business skills, critical thinking skills and communication skills. This assumption is confirmed by research conducted by, amongst others, Behan (1999), Wagner (1997) and Davis (2003). In her 2001 studies Davis (2003) surveyed recently graduated IT professionals to identify technical and non-technical skills required of graduates for a position in the IS/IT field and to gather information on their job titles, tasks, and

ideas about the importance of various skills and content areas to be taught in the curriculum for workplace success. Respondents indicated that the top skills needed for a position in the IS/IT field were thinking skills, teamwork and the desire to learn. Students indicated "a desire to get a well rounded education that provides excellent technical training as well as opportunities to develop thinking skills, personal characteristics, teamwork and communication skills" (Davis, 2003:67).

The School believes that the integration of all three ICT disciplines in the BIT degree provides students with a well-rounded education. Furthermore, students are equipped with business skills through the inclusion of business management, economics, entrepreneurship, statistics, financial accounting and business law. Whilst thinking skills, teamwork and communication skills are emphasised in most courses offered at UP, communication skills are also enhanced through the exposure of students to English reading and writing skills. Philosophy provides students with the opportunity to develop reflective and critical thinking skills. Students also get an opportunity to practice the skills acquired through the first three years of the degree during the time spent with industry in their fourth year. The industry-based learning module (IBL) is seen as an essential part and finishing touch of this degree.

The BIT students are in demand with employers and industry mentors of students in the IBL course are very positive. Many students are offered permanent employment at their IBL employers. Students consider the IBL component to be the main attraction of the degree programme even though the degree doesn't have a conventional and therefore familiar designation (BIT versus BSc (CS) or BCom(Informatics)). Enrolment in the degree tracks enrolment in the School's conventional programmes.

In order to cover all the subjects the BIT degree is a four-year degree in contrast to the regular three-year bachelor degree offered in South Africa. This structure presented challenges when registering the programme with the *South African Qualification Authority* (SAQA), which is registered at NQF/HEQF level 8 that equates it to an honours degree. After completion students are allowed to enter a Masters programme. Although the MIT was envisioned as the next degree many students prefer to pursue a Masters degree specific to a department because the MIT is considered to be an "MBA for IT."

**North-West University's School of IT degrees**

The North-West University (NWU) is a traditional university with its mission "to become a balanced teaching-learning and research university and to implement its expertise in an innovative way." Also important for the design of its degrees is that the NWU want to be "locally engaged, nationally relevant and internationally recognised." The vision of its School of IT (SIT) is to implement the mission of the NWU and also to combine business and IT studies. The SIT programmes are therefore reviewed to find a balance between industry needs and research niches.

The NWU's Vaal Triangle Campus has two faculties, the Faculty of Humanities and the Faculty of Economic Sciences and Information Technology, which comprises three schools: Accounting, Economic Sciences and Information Technology. The School of Information Technology offers Business Mathematics and Informatics (BMI) degrees and Computer Science degrees up to the BSc level, with Information Technology and Operational Research Statistics up to the PhD level. The School of IT has close co-operation with the School of Computer, Mathematical and Statistical Sciences, and the *Centre for BMI* on the Potchefstroom campus of the NWU. All undergraduate degrees are delivered during the day in contact sessions, and are aligned with outcomes.

The BSc (IT) programme includes three modules that are not offered in other degrees in the School of IT: a module in Expert Systems, a module in IT Communication as well as a module in New Developments in IT. In the IT Communication module, students learn Covey's *Seven Habits of Highly Effective People*, as well as communication skills. In the New Developments in IT module the students do projects in serious games, mobile and web technology and databases, amongst others. The IT students also obtain business skills in accounting, business management and management science (decision support systems) modules. All undergraduate students do philosophical 'Understand the World' modules. The School also has a special IT interest group in Robotics. The school also offers an extended BSc (IT) programme that allows students with a lower mark in mathematics to enrol in the programme. This programme uses robotics to make the consequences of programming more visible. This programme is successful, in that the students get more time to spend on the basics.

The BSc Honours (IT) degree was developed at the Vaal Triangle Campus, and currently comprises of 4 modules: Data Mining, Decision Support Systems, Human Computer Interaction and a module in which research methodology and a project are combined. The BSc Honours in Computer Science and Information Systems comprises of a Research Project, as well as 5 modules: Advanced Data Bases, Data Warehousing, Information Systems Engineering, Decision Support Systems and Computer Security.

The Research Project in the Honours degree is used for projects to support research in the school, and it may prepare students for their masters and doctoral studies. The School has experienced study leaders in mobile technology, speech technology, databases and data warehousing, data mining and decision support systems. The problem at the moment is that very few students are interested in mobile and speech technology, although there is enormous capacity in these areas and also a need for skills in this area. NWU is in a process of redeveloping the BSc Honours (IT) degree to address these problems and to cater for the new developments in IT, and to bridge the gap between Business and IT. The BSc Honours degrees are delivered with contact mode after hours to give students the opportunity to work and study.

The Faculty recently established the *Entrepreneurial Development Centre* (EDC), where graduates have the opportunity to develop as entrepreneurs. Some of the students also have the opportunity to work on international, national or local projects in the newly established *Serious Games Institute*, as well as in the newly established niche area in *Mu*ltilingual *s*peech *t*echnology (the *Must* group).

## DISCUSSION

Each university has a unique situation and have responded to the call for development of niches that can enhance their ability to contribute to national objectives. Although the universities offer diverse programmes, common themes do emerge from the case studies. All the case study universities consider industry needs in their curriculum development. Of particular importance is the inclusion of 'soft skills' such as critical thinking and communication skills as well as business management skills. Graduates therefore are equipped to be effective in the workplace in addition to discipline-specific knowledge, skills and competencies. Incorporation of direct experiences in the workplace, offering the benefit of coaching and mentoring from IT practitioners, is not yet extensive but the ICT programmes are positioned well to explore this

opportunity in future. At the same time increasing youth unemployment in the region has contributed to an increased focus on entrepreneurship. Indeed, graduates from SSA should be entrepreneurs to a much greater extent than their counterparts in the developed world and should be able to build their own ICT-based businesses, since small and medium enterprises have proven to contribute significantly to the economic growth in the SSA region (Ogbor, 2009).

Whilst the programmes are responsive to their local contexts, they are also aligned internationally through the adaptation of model curricula, incorporation of globally recognised frameworks and through research networks. Most model computing curricula have become more flexible in their most recent versions, recognizing the diverse contexts in which they may be applied but the three-year Bachelor degree as opposed to four-year duration is still challenging. Where the four-year degree incorporating the Honours-level year was introduced the formal registration of the qualification with the national qualification authority SAQA proved problematic. The need for formalisation of education provision for transferability can limit the ability of institutions to respond to student, industry and even government needs.

Most universities now offer bridging programmes to increase access to their programmes but student interest and enrolment sometimes is a challenge. The programmes all offer sequential progression from the first to the final year of study and are also positioned well to allow students to progress to postgraduate study. In terms of delivery programmes are primarily contact-based except for the dedicated distance education institution, Unisa, and expanding ICT use as instructional technology for blended and online learning is a future possibility.

## CONCLUSION

Whilst there are many challenges in the South African education system and ongoing tensions such as those between formalisation of qualifications and responsiveness, and between localisation and internationalisation remain, the case studies are evidence of reflective academic practitioners at public universities who are actively engaged in improving their schools' ICT curricula to meet government, employer and student needs to ultimately further social and economic development in the region.

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