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ICT SKILLS IN THE LABOUR MARKET: AN OCCUPATIONAL-LEVEL ANALYSIS FOCUSING ON COMPUTER PROFESSIONALS AND ASSOCIATE PROFESSIONALS, 1996-2005

Scarce and critical skills
Research Project

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ICT skills in the labour market:
An occupational-level analysis focusing on computer professionals and associate professionals, 1996-2005

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INTRODUCTION

Information and communication technologies (ICTs) are widely understood to be an enabler of economic growth (UNDP 2001a). South Africa's Deputy President, Phumzile Mlambo-Ngcuka, who launched the Accelerated and Shared Growth Initiative (Asgisa), indicated ICT as an important enabler of growth and development (Mlambo-Ngcuka 2006).

The concern has been expressed to the effect that there is a shortage of ICT skills in South Africa which will act as a restraint on the attainment of government's goal to achieve a sustainable annual six per cent growth rate in GDP and to halve unemployment and poverty by 2014.

Claims about South Africa's apparent ICT skills shortages emanate from a range of sources such as government, training providers, industry, and writers of journal articles and media reports. We will briefly refer to examples from these media regarding the various dimensions of the ICT skills shortage.

Perspectives on ICT skills shortages in South Africa

Technology change

The cyclical nature of the ICT industry is due to influences such as technology obsolescence and changing business requirements and trends, and has led to an ongoing skills shortage locally and globally, says Becky Mosehle, MD of Landelahni Professionals and Technical Appointments (2006).

High level specialist skills such as business analyst and programming skills are important for new generation, sophisticated networks (Carte 2006).

ASGISA

Within the ASGISA initiative business process outsourcing (BPO) and the call centre industry (which requires mainly intermediate ICT skills) is gaining momentum, but higher level ICT skills, such as *management skills* are required for South Africa to become competitive in the global call centre industry.

Management skills

In the near future there will be a premium on appropriate project management skills as integral to upgrading the country's ICT infrastructure. Such skills will be needed *inter alia* to supervise fibre infrastructure and networks that link stadiums to the International Broadcast Centre for the 2010 Soccer World Cup (Mazamisa 2007).

Business skills

The business environment change constantly and ICT systems need to evolve accordingly. Business skills thus need to go hand-in-hand with ICT skills. ICT workers need to go beyond systems and technologies and build their knowledge and skills in business disciplines and the relationships between business functions and finance (Gillingham 2006).

Experience

In March the Star reported that there was a chronic shortage of top SAP systems managers in South Africa (The Star, 5 March 2007). According to an IDC study (Van Heerden 2006), 14 per cent of 20 South African firms will seek advanced international skills among South African nationals who gained experience abroad.

Migration

Countries such as the United Kingdom, Australia, New Zealand, Canada and Germany are experiencing skills shortages in key areas such as IT, engineering, and accounting These countries have been reliant on "brain gain" from emerging markets such as South Africa, India and China (Western Cape Corporate Placements 2006). Meanwhile the South African government is to go head-hunting in India for *ICT experts* amongst others (Fraser-Moleketi 2006)***.***

Equity

There is a shortage of skilled black ICT candidates (Mosehle 2006) and other designated groups in South Africa (Ndlovu 2006). Fulfilling the requirements of the ICT Charter in terms of employment equity is a problem due to a shortage of ICT skills at all levels. More investment is required in skills development and employment equity in the ICT sector, as there has been more recruitment of staff instead of development of resources internally in ICT companies (Coetzer 2007).

Higher education curriculum

In the financial sector executives indicated that higher education ICT departments are weak in the field of *project management* and in understanding the relationship between business and ICT systems (Boltin 2006).

There is a suggestion that higher education institutions themselves suffer ICT skills shortages and that innovative strategies are required to expand the existing ICT pool of skills (Cross & Adam 2007).

Technical skills

Government has identified a continuing need for software engineering skills and for advanced skills in soft and hardware development (Manuel 2007; Fraser-Moleketi 2006). In addition, rising broadband speeds and the emergence of multimedia applications, has fuelled the demand for web developer skills (The Independent 2006). The increase in cyber-crime and cyber intrusion has increased demand for ICT system security and information security skills (Hill 2006; Boltin 2006).

APPROACH OF THIS REPORT

It is necessary to examine the available data to assess whether these statements or views have any validity, as not all sources can be trusted.

We must measure the current size of the ICT workforce or the size of sub-occupational groups within the broader ICT sector in order to provide a sufficiently accurate base for estimating current and likely future demand for workers with these kinds of skills.

Knowing how many workers are currently employed in a particular occupation, and having additional information about their age and qualification levels, should make it possible to generate estimates of how many such occupational workers are likely to cease working and need to be replaced. Calculation of replacement rates involves an estimate of how many similarly – or better - skilled people must be produced through education and training in order to sustain the size of an occupational group whether it is stable, expanding or contracting in response to economic growth and labour market forces.

An investigation of the shape and size of the ICT workforce can generate information about the relative size of the ICT workforce in relation to employment in particular economic sectors or within the whole labour market.

APPLICATION OF NATIONAL SURVEY DATA TO ESTABLISH THE SIZE OF THE ICT WORKFORCE

In order to address the question: "How many ICT professionals are there in the South African workforce?" it is necessary to define what is meant by "ICT", and what is meant by "professional". How this question is approached and the accuracy of the answer is influenced by the type and source of data available.

Our observation is that public discussion about skills shortages in the ICT sector is peppered with multiple claims as to the size of current shortages and magnitude of future skills shortfalls. The scale of claimed ICT skills shortages vary substantially from source to source, as do persistent claims of oversupply and unemployment among ICT graduates.

Estimates of shortages are regularly published in the public domain suggesting a current or likely future ICT skills crisis. Considering the centrality of ICT skills to sustaining economic growth across the South African economy this is perturbing. However, claims that are openly based on the 'gut-feel' of industry insiders, or localized circumstantial evidence have quite limited value.

In other instances, advocates for improving ICT skills supply cite evidence from research studies as to the nature and size of skills shortages. While such privately funded research data may potentially be useful, there is seldom sufficient information given about the methodology through which such data was obtained. It is fundamentally important to have access to such information, because without it, there is no way of knowing whether two studies of the same phenomenon - in this case the size of the ICT workforce – are comparable.

This is why defining what is meant by 'ICT workforce' is so important. For example, a study which defines the ICT workforce as: 'all workers who use a computer', or as 'workers who produce software products and services' or as 'computer engineers' or as 'telecommunications professionals' or combinations of these and other definitions, will each generate quite different estimates of the size of the ICT workforce. ICT workers can be defined with reference to:

- their occupation (eg: Computer Programmer)
- the economic sector within which they work (eg: information technology, telecommunications, banking, insurance, manufacturing etc.). The ICT workforce is not restricted to the ICT sector.
- the field within which they work (eg: networking, Enterprise Resource Planning, IP telephony, Enterprise Application Integration)
- their qualification(s) such as higher degree in Computer Science or a vendor accredited diploma.
- whether their use of a computer is critical to their job description/function in the enterprise.

For these reasons we provide descriptions of the data sources we employ, as well as our occupational definitions of ICT workers.

The data we use is from the October Household Survey (OHS) of 1996 to 1999 and the Labour Force Survey (LFS) of 2000 to 2005. Both of these surveys are designed and administered by the South African government's national statistics agency, Statistics South Africa (StatsSA). The reason why data from two different data sources, the OHS and the LFS are used is because StatsSA terminated the OHS after 1999.

This means that even though the questions to respondents regarding their occupational status and qualifications in the OHS and LFS are similar, the methodology of the two surveys could have differed slightly, such as in the sampling or the weighting of data. As a result of the transition from one survey dataset to another, some discontinuity may be expected between trends expressed in the OHS data from 1996 to 1999, and trends in expressed in the LFS data from 2000 to 2005.

Another challenge arising from the data is high annual fluctuations in the number counts for the key occupational categories to be discussed. This is a product of the process of weighting raw data obtained through a sample to approximate national parameters. Both of the surveys on which this analysis depends - the OHS and the LFS – are based on samples of the national population.

The fluctuations are particularly evident when we disaggregate national employment totals by another category, such as province (x9 sub-categories) or race (x4 categories). In order to smooth out these effects of these fluctuations in both datasets, we decided to create an average for the period covered by each survey. Thus, for the OHS which ran for a period of four years from 1996 to 1999, we generate an annual average employment number per occupational group. Similarly, for the six year period from 2000 to 2005, we create an average employment number. In so doing, we are in a position to establish trends in employment for the ten year period 1996 to 2005. It should be apparent that there is not an even split in the number of years of data between the period before the millennium and the second period post millennium. This is because we considered it more important to retain the integrity of each series of survey data (OHS 1996-1999 and LFS 2000-2005) rather than to group one year of LFS data with the OHS series to create an even five year split for each period.

ESTIMATING THE SIZE OF THE ICT WORKFORCE USING DATA FROM THE OHS AND THE LFS

We will now set out our approach to understanding the size of - and changes in - the ICT workforce.

In estimating the size of the ICT workforce, the investigator must generate a definition that is appropriate to her purposes and that can be operationalised. By appropriate, we mean a definition that accords with the investigators intention to estimate the size of the entire ICT workforce or to estimate the size of a particular sub-category of ICT worker. There are challenges faced in each approach. Adopting a definition that encompasses all ICT workers in an economy presents the challenge of deciding on what basis a worker is or is not an ICT worker.

The more inclusive this definition becomes, the larger the apparent size of the ICT workforce. A fundamental challenge in estimating the size of the entire ICT workforce is first, how to separate out 'end-users' who use productivity tools (eg: spreadsheet, wordprocessor, presentation, scheduling, and other basic 'office' programme) in endless work environments but whose job description is not specifically ICT related.

A second difficulty is how to judge which occupations should or should not be included in the category of ICT workers. For instance, in a number of work environments the core functions and activities central to occupational identity (eg: graphic design) have been migrated almost entirely from the traditional analogue environment into a digital workspace. The flexibility and adaptability of ICT supports the continued diffusion of ICT applications into occupational work environments. Rising levels of integration of ICT into the day-to-day work of different occupations and increased intensity of use of ICT tools continues to impact on the question: what is an ICT worker?

A researcher could design and implement her own survey to gather data, in which case she can define her own sample frame (who will be surveyed) and the kinds of data she requires. But because this kind of survey is very expensive and time consuming, researchers are more typically limited to sourcing data from national statistical agencies which undertake regular labour market surveys. Moreover, national statistical agencies are uniquely positioned to conduct surveys on a regular annual or sub-annual basis, and are frequently the only source of datasets that make longitudinal trend analysis possible.

In the latter case, the researcher is restricted to working with data elements as received from the national statistics agency, the nature of which she would not ordinarily be able to influence. All survey datasets have limitations. The following analysis is therefore limited to what is permitted within the parameters of the OHS and LFS datasets obtained from Statistics SA.

DEFINING ICT WORKERS USING THE SASCO FRAMEWORK

Thusfar we have deliberately used a broad generic term - 'ICT worker' – to refer to the multiple occupational categories in which: people create and produce ICT products and services, or intensively use ICT in the process of fulfilling their particular occupational role.

The South African Standard classification of Occupations (SASCO) list informs how occupational data is captured in the OHS and LFS surveys. It therefore serves as the framework according to which the occupational analysis in this document is undertaken.

There are two core occupational categories employed by the SASCO that can be taken to refer to ICT workers: computer professionals, and computer associate professionals. The SASCO describes the two categories as follows:

- Computer professionals: include computer programmers, system analysts / software engineers, and other computer science professionals
- Computer associate professionals: include assistant system analysts, computer peripheral equipment operators, and robot controllers

This primary categorisation distinguishes between the high level strategic functions of 'computer professionals' and the intermediate level activities of 'computer associate professionals'. These are summarized in Table 1:

Table 1: High level characteristics of 'professionals' or 'engineers' occupations and intermediate level characteristics of 'associate professional' or 'technician' occupations

Standard occupational code (SOC)			**Differences between occupational levels**		
			Skills level	**Qualification**	**Task orientation in workplace**
Computer professionals	**Electronic and telecommunications engineers**		High	Undergraduate degree	More strategic and analytic
Computer associate professionals	**Electronic and telecommunications technicians**		Intermediate	Post-matric certificate or diploma	More operational

The second category refers to workers in the field of electronics and telecommunications engineering. SASCO refers to: 'electronic and telecommunications engineers', and 'electronic and telecommunications engineering technicians' which comprise the following occupations:

- Electronic and telecommunications engineers: include electronic engineers, telecommunications engineers, computer hardware design engineers, and aerospace engineers;
- Electronic and telecommunications engineering technicians: include computer technicians, aerospace technicians, computer hardware design technicians, electronic technicians, and telecommunications technicians;

SASCO separates computer professionals from computer associate professionals, and similarly separates electronic and telecommunications engineers from technicians (See Table 1 above). This is an important distinction to make as it reflects that within occupational fields related to ICT, there are different skills levels.

If we were to count the employment data of only these occupational categories:

- Computer professionals
- Computer associate professionals
- Electronic and telecommunications engineers
- Electronic and telecommunications technicians,

we could claim to have made good progress towards estimating the overall size of the South African ICT workforce. Such a claim would be valid in two important dimensions.

First, in selecting the above four occupational categories, we would be accounting for a large number of workers employed in the ICT sector which comprises: enterprises operating in the field of electronics, enterprises operating in the field of telecommunications, and enterprises operating in the field of information technology(IT).[1] In the latter case enterprises focus on providing software and IT products and services.

Second, the people employed in the four occupational categories would be identified across the economy irrespective of economic sector. The analysis can therefore reveal the numbers employed in these occupations in every sector of the economy such as: mining, manufacturing, electricity, construction, trade, transport, finance, and services. In other words, this study focuses on workers of specified occupations across all sectors of the economy. This is different to focusing only on workers employed in the ICT sector.

Although this approach does provide a sound basis from which to proceed, we must accept that our estimate of the overall national ICT employment numbers based on the number of workers in the above four categories will still be incomplete. It is quite easy to underestimate the size of the ICT workforce if the growing impact of ICT on the business processes and occupational structures of particular industries is not taken into account. We argue that there are a number of occupational categories that in the past two decades have been radically affected by a transformation of the medium within which they work from analogue to digital. The effects of this change are strongly apparent in the media fields of photography, digital broadcasting (including radio and television), multimedia, graphic design and industrial design.

Even though the occupations related to these fields cannot be defined fully as ICT occupations, we should consider them as hybrid occupational forms in which the original skills sets are reshaped by and practiced in a powerful digital environment that provides the substantial benefits arising from convergence of networks, telecommunications services, and content. Consequently, we propose to include in our estimate of the ICT workforce the following ‘hybrid occupations’. They combine high usage of ICT

[1] These enterprises would fall largely within the domain of the South African Information Systems, Electronics and Telecommunications Technologies (ISETT) Sector Education and Training Authority (SETA), which categorises the sector in three subsectors: Electronics, Telecommunications and Information Technology.

applications, high information intensity with 'traditional' skills associated with largely defunct analogue practices:

- Photographers and image and sound equipment operators include photographers, and image and sound equipment (television, motion picture, radio, recording, disc, tape, wire, and sound mixing) operators;
- Broadcasting and telecommunications equipment operators include telecommunications equipment operators, telegraphers, morse code operators, transmitting equipment (television, radio, video, and telecine) operators, and cinema operators
- Graphic or industrial designers include *inter alia* designers of graphic, commercial products, industrial products, jewellery, fashion, interior, textile, package, dress, furniture, motion picture set, display, exhibition, scenery, stage set, poster, advertising, and illustrators of books.

In addition to the inclusion of media-linked occupations, we also recognize that ICT has impacted on demand for certain skills that reside in traditional categories. For example, within the broad occupational category of mathematical professionals, are people who are specialised in operations research which has increasingly been applied in the development of ICT-related systems as explained below:

- Mathematical professionals, as an occupational category includes 'operations researchers'. Operations research is used, *inter alia* 'to improve an entire system' and is strongly applicable in the following ICT-related activities: construction of telecommunications networks at the lowest cost, in designing the layout of a computer chip to reduce manufacturing time and automating human-driven operations processes (Hamdy 2006).

While there is strong evidence that a proportion of mathematicians are operations researchers whose work is dedicated to the design and evolution of various types of ICT systems and products, we cannot include the total numbers of mathematicians counted in the StatsSA surveys. Unfortunately, the OHS and LFS data cannot provide sufficiently disaggregated data which can show what proportion of all persons whose occupation of mathematicians fall into operations research as a sub-category of mathematicians. The way around this problem was to establish whether any other datasource from StatsSA had disaggregated mathematicians. According to the Manpower Survey of 1996, a quarter of all mathematical professionals were operations researchers (Stats SA 1996). We presume that the demand for operations research from the ICT sector has increased since 1996, but will incorporate in our calculations a quarter of the number of mathematicians in our workforce estimates.

In the section that follows, we will now build our estimate of the total ICT workforce in accordance with the foregoing discussion.

PART ONE

Employment size of the ICT workforce

As indicated, we have removed annual fluctuations in employment numbers by creating an average employment figure for each of the two periods 1996-1999 and 2000-2005.

Based on our approach which involves using a broad definition to identify and select a set of occupations as representative of the ICT workforce as a whole, we can report on the following features.

The average annual number of ICT workers employed between 1996 and 1999 was 126 880 per annum, rising to 154 941 per annum in the 2000 to 2005 period (Table 2). Based on these figures, we calculate that employment of ICT workers rose 22.1 per cent between these two periods.

At the occupational level, across the nine year period from 1996-2005 computer professionals and computer associate professionals constituted 20.2 per cent (28 960) and 21.1 per cent (30 353) respectively of the number of workers employed in the identified occupational categories. So, computer professionals and associate professionals constituted over 40 per cent of the ICT workforce within our broad definition of ICT workers which excludes end users but includes media workers.

Between 1996 and 2005, the next largest occupational group was electronic and telecommunication engineering technicians at 26.6 per cent (38 221) whereas the related electronic and telecommunication engineers group constituted only 1.9 per cent (2 661) of the ICT workforce.

It is important to note the 1:1 ratio between higher level computer professionals vis a vis lower skilled computer associate professionals. In contrast, in the electronic and telecommunication engineering field, lower skilled technicians outnumber engineers at a ratio of 14.4:1.

Of the media-related occupations, 3.1 per cent (4 459) were broadcasting and telecommunication equipment operators, 8.1 per cent (11 635) were photographers and image or sound equipment operators and 18.1 per cent (25 950) were graphic or industrial designers, together constituting 29.3 per cent of all ICT workers.

The proportionate share of each occupational group was relatively stable over the nine year period. This is with the exception of the electronic and telecommunication engineering technicians category which increased by 39.3 per cent between the 1996-1999 and 2000-2005 periods. In contrast, electronic and telecommunication engineer numbers decreased by 22.4 per cent. This highlights the relationship between engineers and technicians and requires us to ask what sort of ratio is acceptable in the electronics and telecommunications industry. Further analysis will be required to assess how these ratios evolve and whether they are optimal or sub-optimal (ie: that may reflect shortages of either engineers or of technicians) for sector development.

The ratio of computer professionals as to computer associate professionals was virtually 1 : 1 in the 1996-1999 period and this shifted to 1 : 1.1 in the 2000-2005 period which means that the ratio of employment between these two groups stayed very constant. In contrast, the ratio of electronics and telecommunication engineers to electronics and communications technicians was 1 : 8.9 in the first period rising to 1 : 19.0 in the second period. This doubling in the ratio suggests that the industry was facing a shortage of electronics and communications technicians.

Table 2: Employment of ICT related professionals and associate professionals, 1996 to 2005

ICT occupations	Average employed per annum					
	1996-1999	%	2000-2005	%	1996-2005	%
Computer professionals	27651	21.8	29833	19.3	28960	20.2
Computer associate professionals	27652	21.8	32154	20.8	30353	21.1
Electronics & telecommunication engineers	3074	2.4	2386	1.5	2661	1.9
Electronics & telecommunication engineering technicians	27441	21.6	45408	29.3	38221	26.6
Photographers & image/sound equipment operators	12335	9.7	11169	7.2	11635	8.1
Broadcasting & telecommunication equipment operators	5106	4	4028	2.6	4459	3.1
Graphic / Industrial designers	21480	16.9	28929	18.7	25950	18.1
Mathematicians & related professionals	2140	1.7	1035	0.7	1477	1
Total	126880	100	154941	100	143716	100

Source: Quantec, 2007 (StatsSA OHS data for 1996 – 1999; StatsSA LFS data for 2000 – 2005)

We have presented an approach to estimating the size of the ICT workforce. Our method involved the following. First we identified workers in the following occupations across all sectors of the economy: Computer professionals, Computer associate professionals, Electronic and telecommunications engineers, and Electronic and telecommunications technicians. To this group, we added media-related occupations including graphic design, digital imaging and broadcasting. We argue that the high penetration of ICT in these subfields of media/multimedia, and the evolution of hybrid occupations which combine ICT use with other skills, justifies their inclusion in the calculation of the larger ICT workforce. We also added 'operations researchers/managers', a sub-set of the occupational group of mathematicians and related professionals.

Second, we populated our set of occupations selected from SASCO with data from the OHS and the LFS. Third, we were able to calculate the size of the ICT workforce and of the relative size of the different occupations in relation to the overall ICT workforce.

We briefly review our simple methodology here not to argue for its inherent 'correctness' but rather to present it as one possible approach to estimating the size of the ICT workforce. We recognize that there is probably no single 'correct' approach to estimating the size of the ICT workforce.

More importantly, we have engaged in this exercise to make the point that even though keeping track of national ICT workforce size is important in relation to other macro trends, it is not a statistic that can be used for sector or occupational level planning to inform strategies that can combat skills shortages or oversupply. The reason for this is that the list of occupational types used to obtain an aggregate picture of the ICT workforce should not be analysed together. This is because they constitute totally different occupational labour markets based on ICT sub-sectoral economic activity

To make this point clearer, in the table below, we map ICT occupations against their corresponding ICT sub-sectors as defined by the ISETT SETA.

Table 3: ICT occupations against corresponding ICT sub-sectors as employed by the ISETT SETA	
ICT Sub-sector	**Core ICT occupation**
Electronics Telecommunications	• Electronics and telecommunication engineers (high skill) • Electronics and telecommunication engineering technicians (intermediate skill)
Information Technology	• Computer professionals (high skill) • Computer associate professionals (intermediate skill)

The table shows two occupational groups, each consisting of a complementary high skill and an intermediate skill occupation. These occupational groups have evolved to meet the changing skills/labour inputs required by the respective industry sub-sectors, while education institutions have evolved qualifications to approximate required occupational skills profiles.

Each occupational group is highly specialized so electronics and telecommunications engineers and computer professionals cannot substitute for each other. Each group possesses it's own unique set of knowledge and skills that are obtained through attending specialised post-school and higher education programmes leading to qualifications relevant to the respective fields.

There is evidence of increased convergence between the technology fields of electronics and information technology driven by ongoing product and service development in industry, which may over time lead to increased overlap between these two fields in terms of professional training. Even though the skills and knowledge profiles of electronics and information technology graduates may be slowly converging they still remain relatively independent systems of expertise which respond differently to industry needs. In particular, the demand for computer professionals derives from their participation in a range of business processes ranging from software development to providing consulting services. Consequently, the drivers of demand for 'computer professionals' and for 'electronics and telecommunications engineers' still differs, notwithstanding levels of convergence.

For these reasons, in the analysis that follows we will focus exclusively on two occupational categories, namely computer professionals and computer associate professionals (CPAPs).

Distribution of computer professionals and associate professionals by economic sector

An important starting point for analyzing the distribution of computer professionals in the economy is to assess the propensity for different sectors to absorb these workers. Presumably, sectors in which there is high information intensity will employ higher proportions of CPAPs.

Annual fluctuations in employment data make it difficult to reveal employment trends over the period 1996 to 2005. Averages were calculated at 2-year intervals to moderate the fluctuations.

It is clear from Table 4 that employment of computer professionals is dominated by the financial and business services sector. In fact during the period under review, the financial and business services sector increased its proportionate share of computer professionals. In 1996-1997 half (11 397) of computer professionals and more than a third (9990) of computer associate professionals worked in this sector but these proportions grew strongly. By 2004-2005, as many as 74.3 per cent (22 263) and 70.6 per cent (9 303) of CPAPs respectively were employed in the sector. Put differently, according to the LFS and OHS data, more than seven in every ten Computer professionals were absorbed into the financial and business services sector.

The only other sector which attracted more than 10 per cent of the population of CPAPs was manufacturing. In 1996-1997 10.3 per cent (1 516) of computer professionals worked in manufacturing and this increased slightly to 11.8 per cent (3 538) in 2004-2005. In contrast there was a sharp decrease in the proportion of computer associate professionals employed in the sector, from 20.9 per cent (5 629) in 1996-1997 to 12.7 per cent (1 673) in 2004-2005. The factors contributing to this shift would need to be investigated further.

In the financial and business services sector and in the manufacturing sector, changes occurred in the proportions between employment of high level and intermediate level computer professionals. These changes worked in opposite directions. In the financial and business services sector, the number of intermediate skilled Computer associate professionals increased to the point where there was virtually a 1:1 relationship with the higher skilled Computer professionals. In the manufacturing sector, in 1996-1997 intermediate skilled Computer associate professionals outnumbered Computer professionals by 7:3 but by 2005/2005 the situation was reversed and Computer associate professionals were themselves outnumbered 7:3 by Computer professionals.

It is important to seek explanations for these shifts in the skills make-up of sectors which employ large numbers of CPAPs. Did the ICT skills requirements in these sectors change:

- because new technologies adopted across the industry altered the optimal ratio of ICT high to ICT intermediate skills in enterprises? or,
- because enterprises across the industry adopted new business models which reduced/increased the need for intermediate ICT skills? or,
- because changes in the labour market after 2000 affected the balance of professionals to associate professionals?
- because enterprises created career path opportunities through which workers were promoted to full professional status, perhaps with access to additional training?

Such questions must be posed and adequate explanations need to be found. These are the kinds of questions that will help us to understand the drivers of ICT skills shortages or over-supply and to respond accordingly.

Table 4: Distribution of CPAPs by economic sector, 1996-2005										
ICT occupation by	**1996-1997**		**1998-1999**		**2000-2001**		**2002-2003**		**2004-2005**	
economic sector	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Agriculture	0	0	239	0.7	0	0	0	0	0	0
Mining	271	1.2	629	1.9	132	0.4	345	1.2	305	1
Manufacturing	2314	10.3	2788	8.5	3209	10.2	2405	8.6	3538	11.8
Electricity	366	1.6	413	1.3	637	2	481	1.7	728	2.4
Construction	0	0	0	0	0	0	0	0	0	0
Trade	1516	6.8	318	1	2237	7.1	1362	4.8	610	2
Transport	2047	9.1	2709	8.2	2881	9.2	964	3.4	1085	3.6
Finance	11397	50.8	23284	70.9	19781	63	19738	70.2	22263	74.3
Services	3426	15.3	2475	7.5	2537	8.1	2823	10	1437	4.8
Other Activities	1112	5	0	0	0	0	0	0	0	0
ICT professionals	**22446**	**100**	**32857**	**100**	**31413**	**100**	**28119**	**100**	**29967**	**100**
Agriculture	0	0	74	0.3	0	0	0	0	0	0
Mining	703	2.6	484	1.7	1419	3.2	691	1.8	141	1.1
Manufacturing	5629	20.9	752	2.6	1690	3.8	4778	12.3	1673	12.7
Electricity	280	1	469	1.7	1041	2.4	470	1.2	109	0.8
Construction	0	0	626	2.2	0	0	188	0.5	0	0
Trade	2896	10.8	2531	8.9	3852	8.7	3131	8	1008	7.7
Transport	4732	17.6	1842	6.5	3058	6.9	4429	11.4	937	7.1
Finance	9990	37.1	18364	64.7	25107	56.7	21464	55	9303	70.6
Services	1791	6.7	3237	11.4	7802	17.6	3592	9.2	0	0
Other Activities	908	3.4	0	0	0	0	258	0.7	0	0
Unspecified	0	0	0	0	316	0.7	0	0	0	0
ICT associate professionals	**26927**	**100**	**28378**	**100**	**44286**	**100**	**39002**	**100**	**13172**	**100**

Source: Quantec, 2007 (StatsSA OHS data for 1996 – 1999; StatsSA LFS data for 2000 – 2005)

Similar questions are relevant also to sectors which employ smaller numbers of computer professionals, such as the ‘Trade’ and the ‘Transport storage and communications’ and ‘Social and personal services’ sectors. We simply make this general point about the employment of Computer professionals in these sectors without analyzing the detail. This is because, as we have observed earlier, small numbers in the data returns from limited sample surveys such OHS and LFS are weighted to approximate the total numbers of the population in the sample frame, and there is some doubt as to the reliability of small numbers in the tables, because of this. This is why it is appropriate to interrogate this data in order to draw out the broad trends and not to engage on a very detailed level with small numbers. For example, it is very unlikely that in the entire construction industry there were zero Computer professionals or associate professionals employed!

Distribution of computer professionals and associate professionals by industry

Our analysis shows that eight out of ten CPAPs worked in the financial and business services sector or in the manufacturing sector. Given the need to be circumspect about the validity of small numbers, we decided to disaggregate only these two sectors at the industry level.

Over the 2004-2005 period, within the financial and business services sector the overwhelming majority (54.5 per cent) of CPAPs worked in software consultancy and supply, while 13.6 per cent worked in the hardware consultancy, 7.2 per cent worked in monetary intermediation (plus 2.5 per cent in 'other financial intermediation'), and 4.4 per cent worked in legal, accounting, bookkeeping and auditing environments (Table 5). There is a relatively sizeable share of employees in 'other computer related activities' but further investigation would be required to establish what constitutes this group.

Turning to the manufacturing industry, the bulk of CPAPs working in manufacturing were employed in motor vehicle manufacture (54.1 per cent) with a further 16.9 per cent working in the manufacturing of office, accounting and computer machinery industry. Relatively small numbers were employed in the manufacture of basic iron and steel (8.1 per cent) and of electronic components (7.6 per cent). The latter statistic gives some indication of how small the electronic component manufacturing sector is in South Africa, while the much larger percentage working in the manufacturing of office accounting and computer machinery sub-sector are engaged largely in assembly of computers rather than manufacturing.

Table 5: Distribution of CPAPs by sub-industry, 2004-2005

Detail Industry	CPAPs	
	n	%
Manufacturing		
Petroleum refineries / synthesisers	278	5.3
Manufacture of basic iron and steel	420	8.1
Manufacture: Office, accounting & computer machinery	879	16.9
Manufacture: Electronic components	398	7.6
Manufacture of motor vehicles	2819	54.1
Manufacture of bodies for motor vehicles	207	4
Manufacture of furniture	211	4
Total	**5211**	**100**
Financial and Business Services		
Monetary intermediation	2264	7.2
Other financial intermediation n.e.c.	803	2.5
Renting of other machinery and equipment	139	0.4
Hardware consultancy	4290	13.6
Software consultancy and supply	17203	54.5
Data base activities	722	2.3
Maintenance of office, accounting & computer machinery	51	0.2
Other computer related activities	3391	10.7
Legal, accounting, bookkeeping and auditing activities	1392	4.4
Architectural, engineering & other technical activities	573	1.8
Business activities n.e.c.	737	2.3
Total	**31566**	**100**

Source: Quantec, 2007 (StatsSA LFS data for 2004 – 2005)

Distribution of computer professionals and associate professionals by province

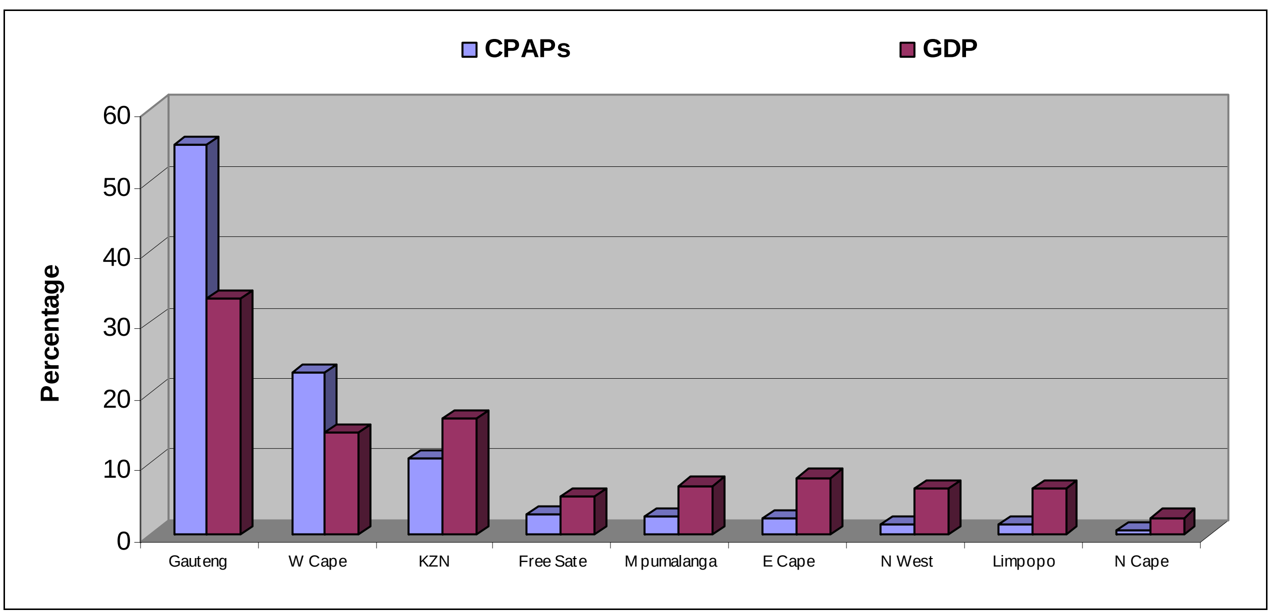
At the macro level, it is important to analyse the spatial distribution of computer professionals, since this provides a sense of the broad labour market situation within which local ICT skills shortages and oversupplies can be contextualized.

The importance of the provincial distribution is immediately apparent when we see that practically nine in every ten computer professionals is located in one of three provinces: Gauteng (55.2 per cent), Western Cape (23.0 per cent) and KwaZulu-Natal (10.7 per cent). In each of the other six provinces the share of computer professionals is below 2 per cent.

We would expect Gauteng, the Western Cape and KwaZulu-Natal to attract the highest proportion of computer professionals, because they are the three largest provincial economies. A simple comparison between percentage share of computer professionals employed and percentage contribution to the national GDP bears this general assumption out. However, the comparison reveals how the share of computer professionals in Gauteng and the Western Cape is disproportionately larger than their contribution to GDP (Figure 1 and Table 6). The concentration of industry types which are high intensity users of computer professionals (eg: computer services, financial services, banking and insurance,) in metropolitan areas such as Cape Town and Durban explains the higher density of computer professionals relative to GDP in the Western Cape and KwaZulu-Natal provinces. In addition, large urban areas with better amenities and larger job-markets with more opportunities also tend to attract computer professionals.

This high-level picture tells us how the supply and demand of computer professionals must be understood in a spatial dimension. Clearly difficulties in filling computer worker vacancies will be experienced in the provinces which have smaller GDPs and an even smaller computer professional workforce. We can further infer that the spatial concentration of ICT professionals will be mainly in urban settlements which will further distort access to ICT professionals in provinces where the population is largely rural.

Figure 1: Provincial distribution of CPAPs and Gross Domestic Product (GDP), 2000-2005 (average per annum)



Source: Quantec, 2007 (StatsSA LFS data for 2000 – 2005)

Table 6: Provincial distribution of CPAPs and GDP, 2000 to 2005			
Province	Average employed p.a. (2000 – 2005)		GDP
	n	%	%
Gauteng	34246	55.2	33.4
Western Cape	14241	23.0	14.5
KwaZulu-Natal	6625	10.7	16.5
Free Sate	1789	2.9	5.4
Mpumalanga	1598	2.6	6.9
Eastern Cape	1335	2.2	8.1
North West	935	1.5	6.5
Limpopo	912	1.5	6.5
Northern Cape	306	0.5	2.4
Total	61987	100	100

Source: Quantec, 2007 (StatsSA LFS data for 2000 – 2005)

Distribution of computer professionals and associate professionals in the public sector

South African provincial and national government departments and institutions, and municipalities at local government spheres constitute the single biggest corporate market for computer hardware, software and services in the country.

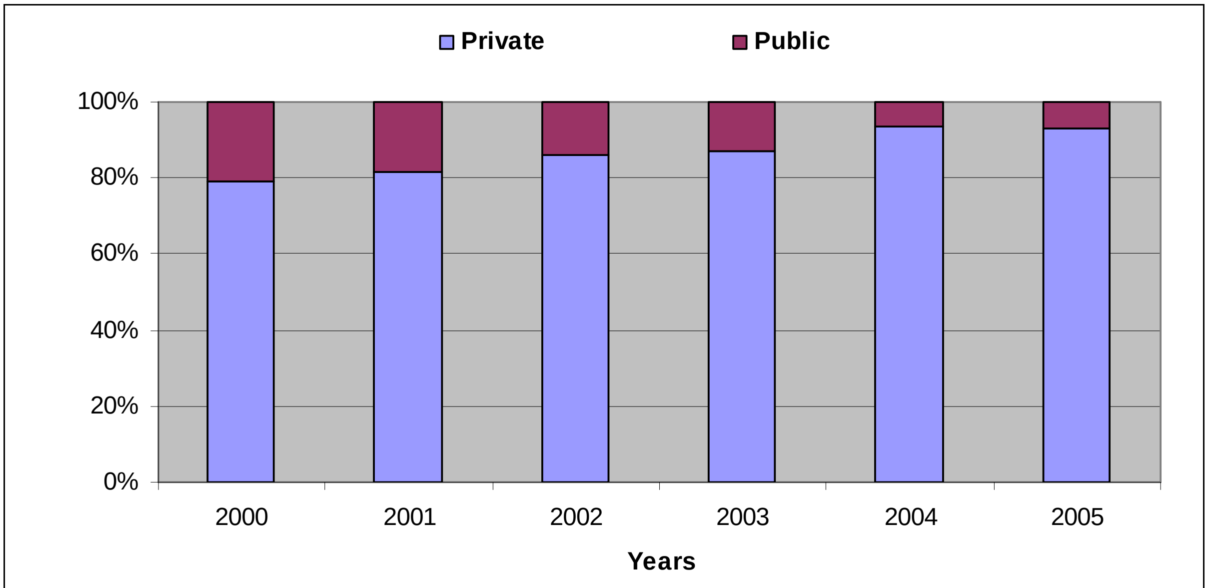
Furthermore, government is pursuing an e-government programme which involves plans to improve its use of ICT in order to generate greater efficiency and effectiveness within the machinery of government. Challenges such as improving exchange of data between departments for better decision making and coordination, and improving government human resources and personnel management systems are being addressed. In the latter case, several government departments are collaborating on the development of a new Integrated Financial Management System (IFMS) which includes payroll and administrative functions to service over a million government workers in the provincial and national spheres.

While the above activities relate to government's intent to strengthen its internal systems of management and administration, government must also begin to deploy ICTs as an important channel of service delivery for the future. This is signaled through the growing emphasis on placing Multi-Purpose Community Centres (MPCCs) on a national basis as physical points at which citizens should be able to access ICTs and to activate government e-services.

Consequently one might expect that for the above reasons, the computer professional workforce in government will be increasing in size. Contrary to this assumption, there has been a gradual decrease in the number of CPAPs in the public sector over the period 2000 to 2005. In real terms, government CPAPs exceeded 14000 workers in 2000 and 2001, but since then declined to below 3000 before recovering to above 3000 in 2005. Private sector employment of CPAPs also declined in the period though not as sharply.

If we look at proportionate share of employment in 2000, 79.3 per cent of CPAPs worked in the private sector and 20.7 per cent in the public sector, whereas in 2005 as many as 93.1 per cent of CPAPs worked in the private sector and only 6.9 per cent in the public sector, as shown in Figure 2.

Figure 2: Distribution of CPAPs by public and private sector, 2000 to 2005



Sector	2000	2001	2002	2003	2004	2005
Private sector	53991	62776	67908	48003	34224	46241
Public sector	14091	14358	11089	7243	2366	3447
Total	68082	77134	78997	55246	36590	49688

Source: Quantec, 2007 (StatsSA LFS data for 2000 – 2005)

According to Figure 2, the public sector appears to have shed as many as ten thousand computer professionals in the five year period. However, this shift does not necessarily reflect a direct loss of ten thousand computer professionals from the workforce employed to operate government ICT systems. It is more likely to reflect increased resort on the part of government to outsourcing its IT functions to private companies which design implement and maintain government IT systems.

This occurs where workers formerly employed by the client, in this case a government department, become employed by a service provider - a private sector enterprise - which takes over the outsourced functions. However, this process seldom involves direct transfer of a group of public sector computer professionals into the employ of private enterprises. The outsourced contractor will seek to improve the alignment of IT systems with business processes. In the transition towards an outsourced model, new skills needs will become apparent while other skills will become surplus and may involve job-shedding.

This process is probably impacting on the accuracy of the OHS data itself. Respondents are required to indicate whether they are employed in the public or the private sector. These responses may become steadily less useful in estimating the ICT workforce in government because more workers will be employed by private sector enterprises, though they are actually working on government projects. This can lead to a significant underestimate of ICT employment that is dependent on government projects.

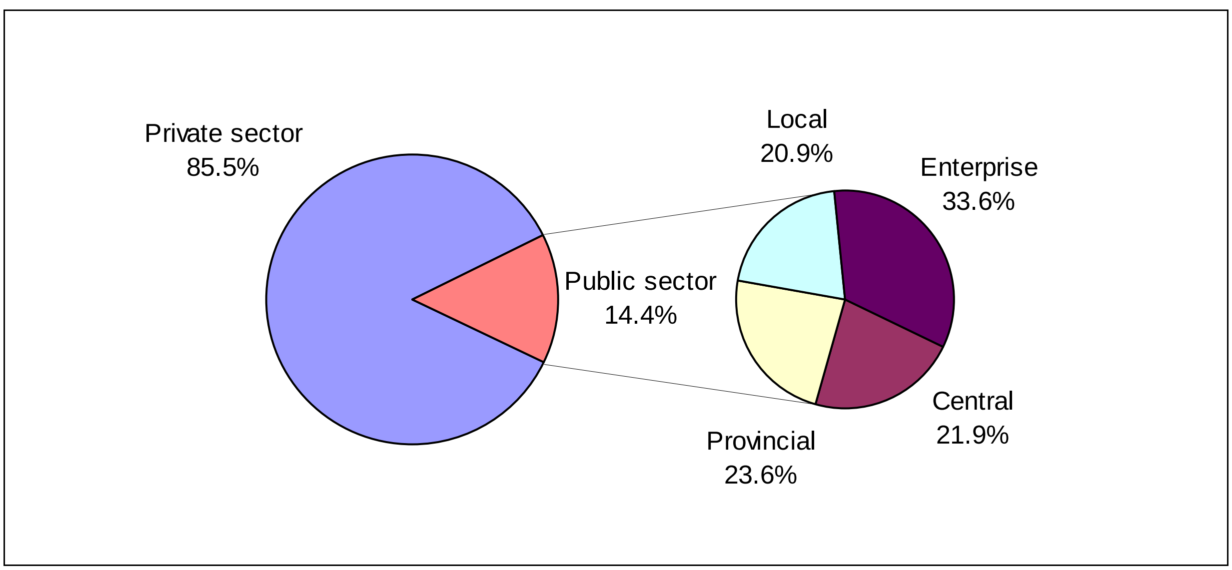
There are several important issues embedded in government outsourcing ICT work. Firstly, the public sector has always struggled to staff its IT functions, largely because of attractive private sector wages that draw former public sector IT workers in to the private sector labour market. This is a serious concern for sustaining the integrity of government information and decision support systems in general. It is also problematic since certain government information functions cannot be outsourced for reasons of security and sensitivity.

Second, we must question whether private sector enterprises which are benefiting from outsourced public contracts are paying sufficient attention to training appropriately skilled people to fulfill their contracts. Claims by private sector companies who are contracted to government about skills shortages may reflect a combination of an alreading existing poor government skills base and a continuing low propensity for private companies to train.

Third, there may well be an actual increase in overall skills demand as a result of overall increases in government investment in ICT projects – whether these be in-house or outsourced - thus raising a national need for ICT skills. How this need is quantified remains a challenge when there are nearly 150 provincial and national government departments and over 260 municipalities.

Fourth, we must give consideration to the extent of computer professional employment accross the different spheres of government which includes local, provincial, national and state owned enterprises. The figures averaged for the period 2000 to 2005 suggests that state owned enterprises employ the largest number of such professionals (33.6 per cent) followed by provincial, central and local government at 23.6 per cent, 21.9 per cent, and 20.9 per cent respectively (Figure 3). The most striking statistic is that provinces employed only 23.6 per cent of government CPAPs, yet there are nearly 100 provincial level departments with massive service delivery responsibilities including education, health and social welfare in this sphere. This suggests that ICT outsourcing is mainly resorted to at the provincial and national spheres.

Figure 3: Distribution of CPAPs by private sector and detail public sector, 2000 to 2005



Source: Quantec, 2007 (StatsSA LFS data for 2000 – 2005)

The provincial distribution of CPAPs compared to the numbers of all government workers by province provides insight into the ICT skills base at the provincial level. Table 7 shows that over the 2000-2005 period, the highest concentrations of government employed CPAPs were located in Gauteng (0.9 per cent), the Western Cape (0.5 per cent) and in KwaZulu-Natal (0.5 per cent). Provinces with very small cohorts of CPAPs were the Eastern Cape, the North West and Mpumalanga. These significant differences would be further compounded in provinces covering large areas making access to computer professional services difficult because of travel and time costs. These environments will constrain the capacity of government to upgrade let alone innovate in its use of ICT.

Table 7: CPAPs in government as percentage of all government workers per province

Province	(a) Average number of government servants employed p.a., 2000 - 2005	(b) Average number of CPAPs employed p.a. in government, 2000 - 2005	b/a
	n	n	%
Western Cape	242658	1175	0.5
Eastern Cape	231765	195	0.1
Northern Cape	44099	20	0
Free Sate	137825	509	0.4
KwaZulu-Natal	369353	1694	0.5
North West	134286	122	0.1
Gauteng	462638	4282	0.9
Mpumalanga	105146	191	0.2
Limpopo	190443	576	0.3
Total	1918213	8766	0.5

Source: Quantec, 2007 (StatsSA OHS data for 1996 – 1999; StatsSA LFS data for 2000 – 2005)

Distribution of computer professionals and associate professionals according to skill level

Change in the skill levels of CPAPs as an occupational group is a matter of significant interest in the context of discussions on demand and supply. One of the reasons for this is that the field of information and communication technology is rapidly evolving and as a consequence a premium is placed on skills levels and on the currency of skills.

The theory of skills biased technology change (SBTC) holds that in the general labour market, there is a tendency for technology driven change to generate relatively stronger demand for higher than for lower skills. Does SBTC also apply to the occupational categories: computing professionals and associate computing professionals? We can address this question by considering whether, over time there was any change in the occupational skills levels of computer professionals and of computer associated professionals.

For example, if the general skills levels of computer professionals have increased relative to the general skills levels of associate computer professionals, there may be cause to entertain the possibility that SBTC has influenced these changes. It will not be possible to judge this question authoritatively for these occupations, because even though each is named a ‘profession’ the occupational category of ‘computer professionals’ is quite broad, covering a range of sub-occupations. Unlike certain other professional categories such as engineers, lawyers and medical practitioners whose membership is regulated and entry qualifications are quite specific, computer professionals are a heterogeneous group with no overarching professional body and many public and private qualification pathways leading to practice job acquisition and practice. For these reasons, we will examine the data with a view to establishing whether the general qualifications levels of the two broad groups of occupations have changed between the two periods.

We must reiterate that the two periods were reported on through two different instruments, namely the LFS and the OHS. Consequently we cannot ignore the possibility that shifts identified in the shape of qualifications for each period may have been influenced by differences between the two surveys rather than by changes in reality.

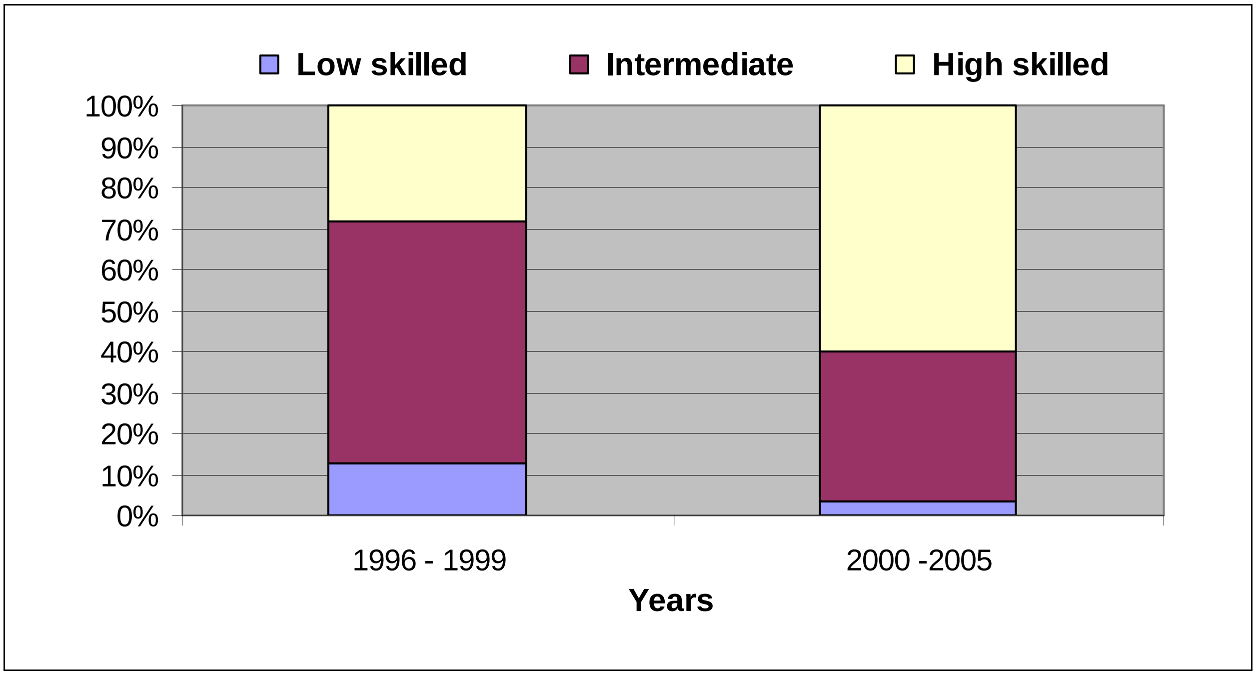
There are two significant changes in the distribution of skill levels among computer professionals. First, over the 1996-1999 period as many as 12.5 per cent of Computer professionals were low skilled, whereas over the 2000-2005 period this proportion dropped to only 3.2 per cent (Table 8). Second, in the early period just over a half of Computer professionals were high skilled, whereas in the latter period, this proportion had grown to 59.5 per cent, as shown in Figure 4.

Table 8: CPAPs according to level of skill, 1996 to 2005

Level of skill	1996-1999		2000-2005	
	Average p.a.	%	Average p.a.	%
Computer professionals				
Low skilled	3464	12.5	959	3.2
Intermediate	16270	58.8	10863	36.4
High skilled	7776	28.1	17752	59.5
Unspecified	141	0.5	259	0.9
Total	27651	100	29833	100
Computer associate professionals				
Low skilled	2937	10.6	5243	16.3
Intermediate	23626	85.4	24803	77.1
High skilled	848	3.1	1891	5.9
Unspecified	242	0.9	217	0.7
Total	27652	100	32154	100

Source: Quantec, 2007 (StatsSA OHS data for 1996 – 1999; StatsSA LFS data for 2000 – 2005)

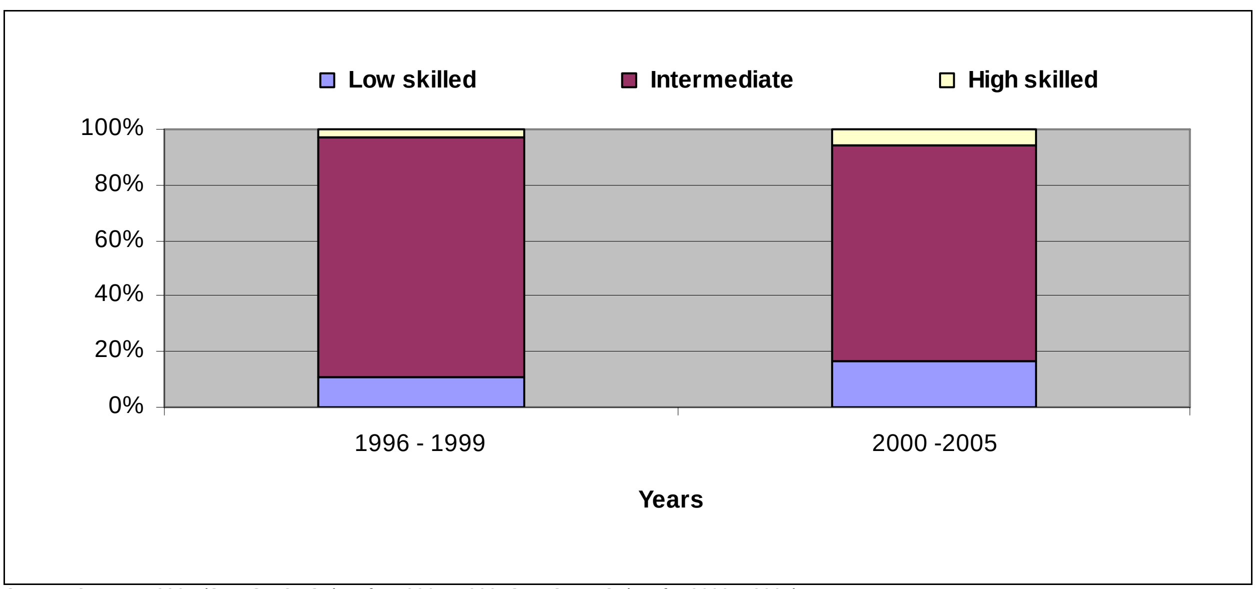
Figure 4: Computer professionals according to level of skill, 1996 to 2005



Source: Quantec, 2007 (StatsSA OHS data for 1996 – 1999; StatsSA LFS data for 2000 – 2005)

In the case of the Computer associate professionals, intermediate skills workers were in the overwhelming majority, despite losing some ground in the second period from 85.4 to 77.1 per cent. The low skill proportion increased from 10.6 per cent to 16.3 per cent and the high skill proportion increased from 3.1 per cent to 5.9 per cent (Table 8; Figure 5). The increased proportion of low skill workers may indicate a shortage in the labour market of workers with intermediate skills. These shifts would require further investigation to assess the underlying influences.

Figure 5: Computer associate professionals according to level of skill, 1996 to 2005



Source: Quantec, 2007 (StatsSA OHS data for 1996 – 1999; StatsSA LFS data for 2000 – 2005)

Among workers employed as computer professionals, the heterogeneity of skills reduced substantially. At the same time the distribution of high skills among computer professionals rose markedly from 28.1 to 59.5 per cent between 1996-1999 and 2000-2005.

For workers employed as associate computer professionals, the proportion holding high skills and holding low skills increased. This meant that the majority share of computer associate professionals holding intermediate skills declined from 85.4 per cent in the first period to 77.1 per cent in the second period. It appears the heterogeneity of skills increased among computer associated professionals. These changing distributions are probably influenced by a combination of hiring practices on the demand side and skills improvement on the supply side, over the period.

The general pattern of recruiting associate computer professionals with intermediate skills and recruiting computer professionals with high skills was retained between the two periods. The fact that a marked increase in proportions of professionals with high skills took place over the 2000 to 2005 period suggests that the education and training supply side institutions did contribute substantially to raising skills among professionals.

But this does not necessarily mean that complaints about an ICT skills shortage were unfounded. The relatively large proportion of intermediate skilled workers in the computer professional category (36.4 per cent) and the high proportion of 16.3 per cent low skill workers in the computer associate professionals category indicate that a shortage was in evidence in the second period.

When the two high level occupational categories used above are decomposed at the sub- occupational level, the general pattern consolidation of skills per occupational level is visible (Table 9). As observed above, the small proportions of low-skilled workers among computer professionals suggests that the extreme shortage of appropriately high skilled workers in the 1996-1999 period was ameliorated by the second period. What this breakdown does demonstrate is that there is considerable variation between the sub-occupations in terms of aggregate worker skills levels. Computing professionals category turned out to be the best stocked in terms of appropriate skill levels. Because the skills range of computer associate professionals ranges quite widely, we are less confident in pointing to specific shortages.

Table 9: Computer sub-occupations according to level of skill, 1996-2005					
Detail Computer occupation	**Level of skill**	**1996-1999**		**2000-2005**	
		Average p.a.	**%**	**Average p.a.**	**%**
Computer Professionals					
Software engineers / Analysts	Low skilled	289	4.3	599	7.3
	Intermediate	3443	51.2	3092	37.5
	High skilled	2994	44.5	4550	55.2
	Unknown	0	0	0	0
	Total	6726	100	8241	100
Computer programmers	Low skilled	2722	15.3	360	2.3
	Intermediate	11222	62.9	6824	43.2
	High skilled	3890	21.8	8366	52.9
	Unknown	0	0	259	2
	Total	17834	100	15809	100
Computing professionals nec.	Low skilled	453	14.7	0	0
	Intermediate	1605	51.9	947	16.4
	High skilled	892	28.8	4836	83.6
	Unknown	141	4.6	0	0
	Total	3091	100	5783	100
Computer associate professionals					
Assistant computer analysts	Low skilled	1315	9.4	3025	12.6
	Intermediate	11969	85.6	19497	81.1
	High skilled	547	3.9	1315	5.5
	Unknown	158	1.1	217	0.9
	Total	13989	100	24054	100
Computer equipment operators	Low skilled	1084	8.8	1479	28.3
	Intermediate	10781	88.0	3635	69.6
	High skilled	301	2.5	105	2.0
	Unknown	84	0.7	0	0
	Total	12250	100	5220	100
Computer technicians	Low skilled	537	38.0	738	25.6
	Intermediate	876	62.0	1671	58.0
	High skilled	0	0	471	16.3
	Unknown	0	0	0	0
	Total	1413	100	2879	100

Source: Quantec, 2007 (StatsSA OHS data for 1996 – 1999; StatsSA LFS data for 2000 – 2005)

Distribution of persons with qualifications in ICT related fields in the workforce

As part of an overview of the supply and demand situation for workers to fill 'computer professional' and 'computer associate professional' posts it is appropriate to look at the proportion of those employed who have a qualification in the field of ICT.

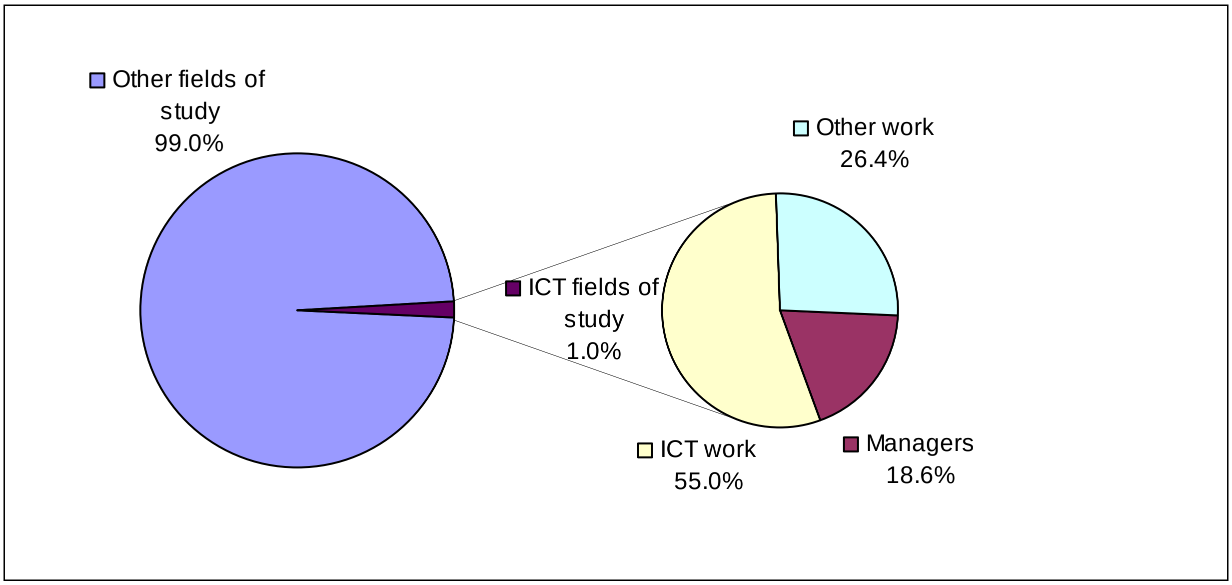
Over the period 2000 to 2005, one per cent (112 690 annual average) of all employed (11727 903 annual average) workers held qualifications in *ICT related fields of study.*

It should be noted that the 'ICT related fields of study' category in the LFS dataset is not 'pure', and will necessarily include workers who will have studied other physical, mathematical, and life science fields as well as computer related subjects.

What we are particularly interested in is the work status of persons who claim to have qualifications in an ICT related field of study, since this number is central to understanding the supply of qualified people into the labour market.

It is interesting to note that of those who reported having studied for a qualification in an *ICT related field of study,* 55.0 per cent worked as CPAPs, 26.4 per cent did other work and 18.6 per cent were in managerial positions (Figure 6).

Figure 6: Type of employment among workers with a qualification in an ICT related field of study, 2000-2005



Source: Quantec, 2007 (StatsSA OHS data for 1996 – 1999; StatsSA LFS data for 2000 – 2005)

What this data tells us is that not all persons who graduated with a qualification from a higher education institution in an ICT related study and who were employed in the period 2000-2005 actually worked as CPAPs. Based on an annual average calculated for the period, about 55 per cent occupied positions as computer professionals, while nearly one-in-five were managers in any sector. One in four graduates were employed in work other than an IT professional or associate professional.

These ratios are important because they demonstrate that in the labour market, a proportion of graduates from higher education with an IT-related skill may actually be employed in other occupations. This alerts us to the likelihood that of every cohort of graduates from higher education – or from other institutions – a certain proportion will never work as IT professionals while others will switch to non-ICT occupations at some point in their career.

Further analysis involving a breakdown of these numbers by age in particular will be valuable. We also need insight into when persons with an ICT-related qualification take up employment as managers is also important, since a large proportion of qualified workers are in a managerial position rather than a professional position. Such information will enable more sophisticated modeling of ICT skills demand.

Employment of computer professionals and associate professionals by race

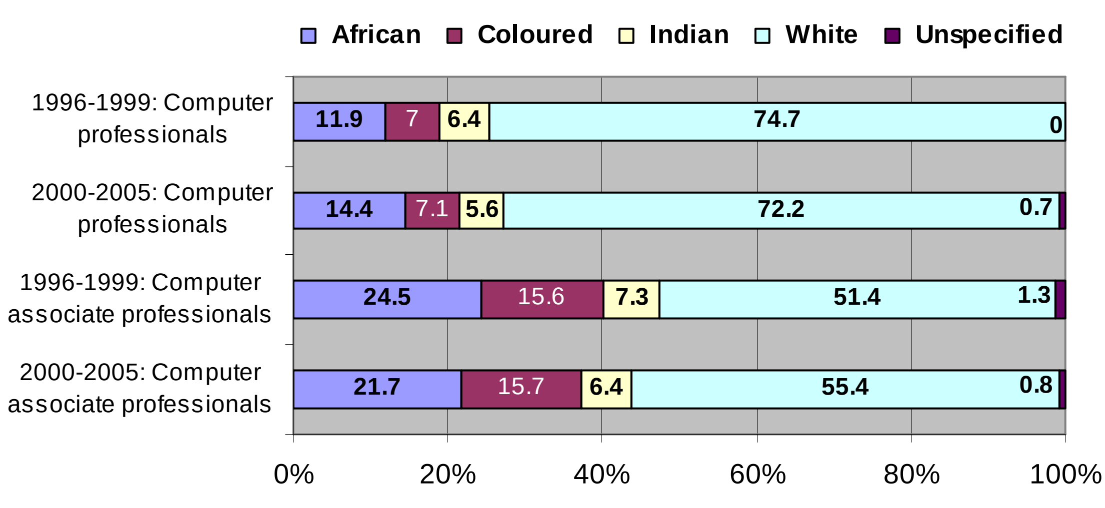
A key question in the post-Apartheid labour market is the extent to which employment equity has taken root. For this reason it is necessary to consider how transformation in terms of access to jobs is taking place at the computer professional level and the associate level.

Before looking at the race share of employment in each occupational group, we observe that in the case of computer professionals, there was an overall increase of 7.9 per cent in employment between the 1996-1999 and the 2000-2005 periods (Figure 7 and Table 10). Among computer associate professionals there was a more substantial 16.3 per cent increase in employment over the same period.

Looking first at computer professionals, the percentage of African and coloured computer professionals increased by 2.5 per cent and 0.1 per cent respectively between the 1996-1999 and 2000-2005 period. At the same time, the percentage of Indian and white computer professionals decreased by 0.8 per cent and 2.2 per cent respectively. Thus marginal improvements were recorded amounting to a 1.8 per cent increase in the proportions of black computer professionals between the two periods.

Among Computer associate professionals, there was a 4 per cent increase in the percentage of white workers, a small increase among coloured workers (0.1 per cent) and decreases in the percentage of Indian (-0.9 per cent) and African (2.8 per cent) workers. Even though there was an increase in the real numbers of all groups, the real and proportional gains were made among white associate professionals representing a regressive shift in terms of equity needs.

Figure 7: Employment of CPAPs by race, 1996 to 2005



Source: Quantec, 2007 (StatsSA OHS data for 1996 – 1999; StatsSA LFS data for 2000 – 2005)

Table 10: Employment of CPAPs by race, 1996 to 2005

Race	Computer professionals				Computer associate professionals			
	1996-1999		2000-2005		1996-1999		2000-2005	
	n	%	n	%	n	%	n	%
African	3293	11.9	4288	14.4	6764	24.5	6968	21.7
Coloured	1939	7.0	2124	7.1	4306	15.6	5061	15.7
Indian	1761	6.4	1672	5.6	2016	7.3	2058	6.4
White	20658	74.7	21552	72.2	14208	51.4	17817	55.4
Unspecified	0	0.0	196	0.7	357	1.3	250	0.8
Total	**27651**	**100**	**29833**	**100**	**27652**	**100**	**32154**	**100**

Source: Quantec, 2007 (StatsSA OHS data for 1996 – 1999; StatsSA LFS data for 2000 – 2005)

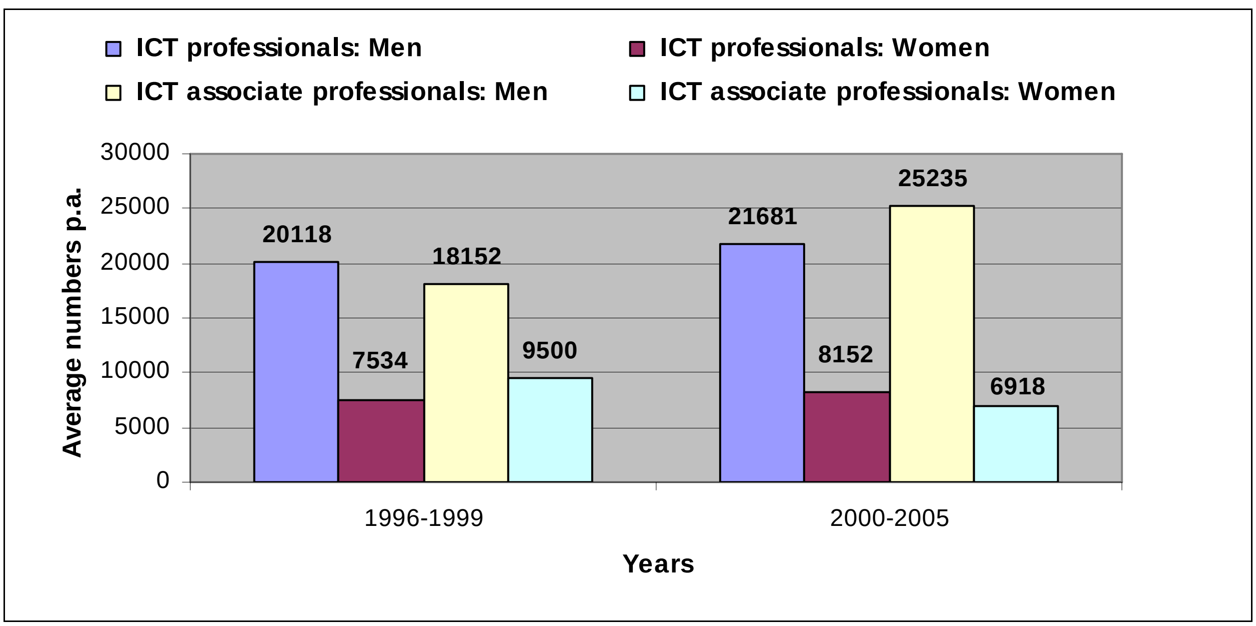
Employment of computer professionals and associate professionals by gender

The gender composition of the computer professional occupational categories has worsened between 1996-1999 and 2000-2005. Over the 1996-1999 period females comprised 30.8 per cent of all CPAPs. Over the 2000-2005 period the proportion of females declined to 24.3 per cent (Figure 8). In effect, female CPAPs suffered a negative average annual growth of minus 4.1 per cent for the full period 1996 to 2005.

If we disaggregate these figures according to the two occupational categories, we see that there was an increase in the numbers of females working as computer professionals from 7534 to 8152 between the 1996-1999 and 2000-2005 period. On the other hand there was decline in the employment of females in the associate professional category from 9500 to 6918.

Conversely, there was growth in both the male computer professional category (20118 to 21681) and the associate professional category (18152 to 25235) between the 1996-1999 and the 2000-2005 period. Clearly, these conditions privileged male employment.

Figure 8: Employment of CPAPs by gender, 1996 to 2005



Source: Quantec, 2007 (StatsSA OHS data for 1996 – 1999; StatsSA LFS data for 2000 – 2005)

Employment of computer professionals and associate professionals by race and gender

In this section we further explore the question of equitable access to employment in the occupations of CPAP by examining race and gender representation.

The numbers of black and white male CPAPs increased over the 1996 to 2005 period, while the numbers of their female counterparts decreased (Table 11). In terms of annual average growth over the period, black male and white male representation increased by 2.3 per cent and 2.5 per cent respectively. Simultaneously, the average annual employment of black and white females declined by 2.2 per cent and 1.1 per cent respectively between 1996 and 2005. Black and white females fared badly both in real numbers and in terms of their proportionate share of employment in the two occupational categories.

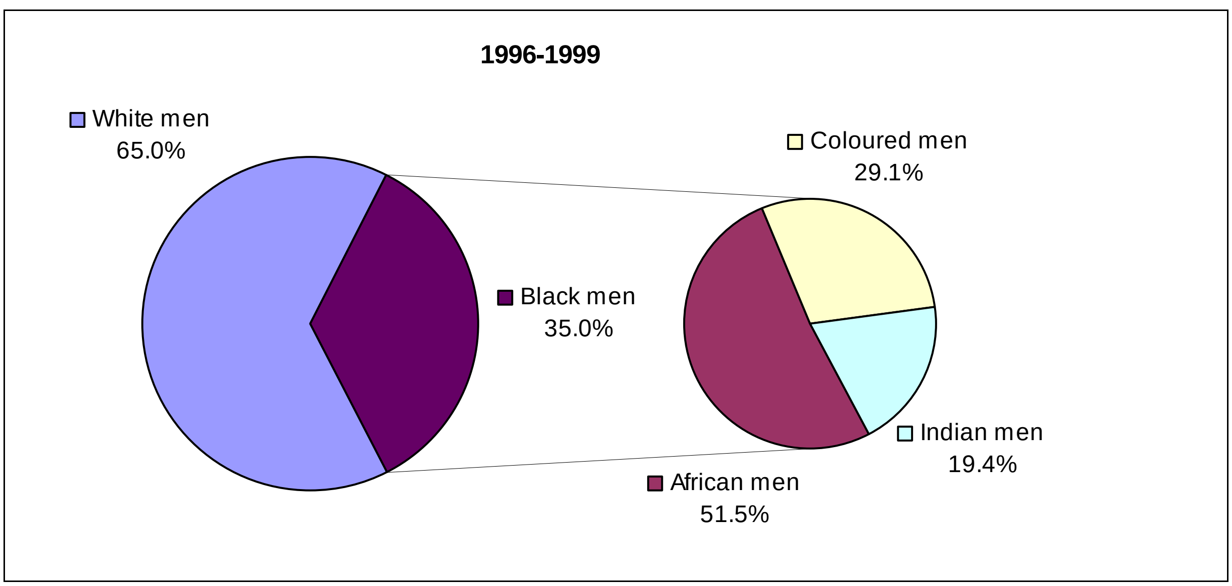
Table 11: CPAPs by race and gender, 1996 to 2005

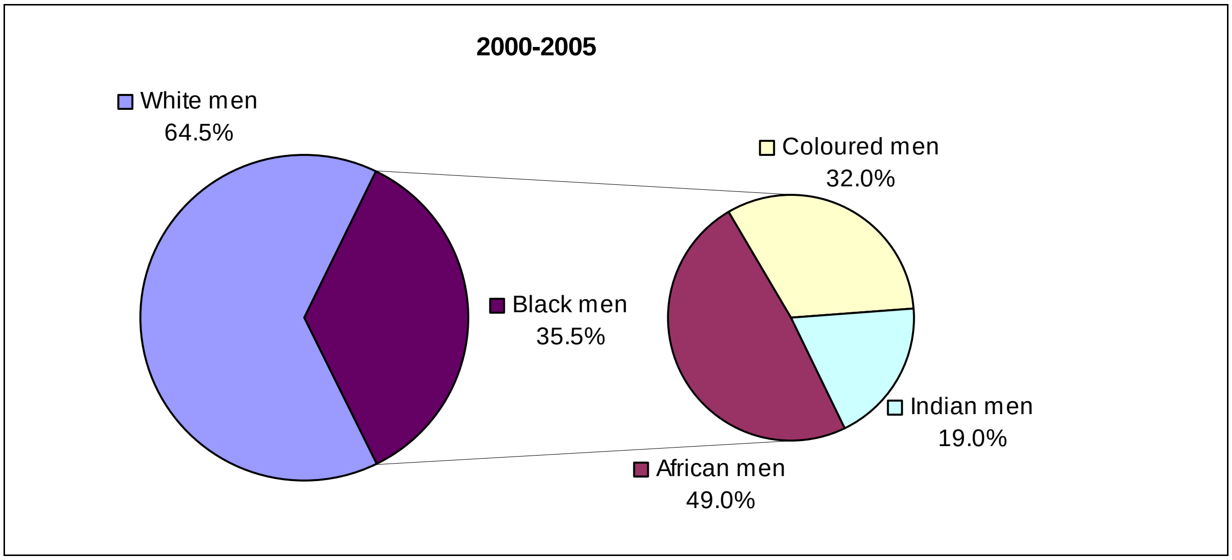
Gender and race	Average employed per annum 1996-1999	%	2000-2005	%	Average annual growth %
Black males	13278	24.2	16583	26.9	2.5
White males	24634	44.8	30102	48.8	2.3
Black females	6802	12.4	5785	9.4	-2.2
White females	10233	18.6	9267	15	-1.1
Total	54946	100	61737	100	1.3

Source: Quantec, 2007 (StatsSA OHS data for 1996 – 1999; StatsSA LFS data for 2000 – 2005)

If we examine the race share of employment among male CPAPs we see that there was relatively marginal change between the two periods which are characterized by white males commanding the largest share (Figure 9).

Figure 9: Male CPAPs, 1996 to 2005

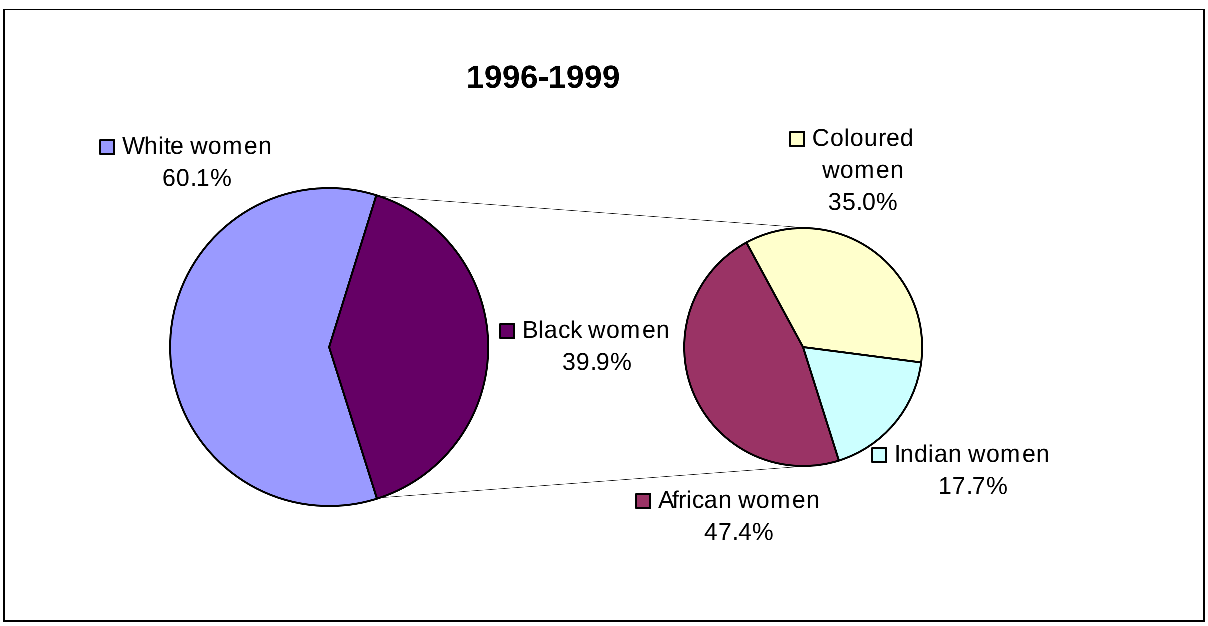


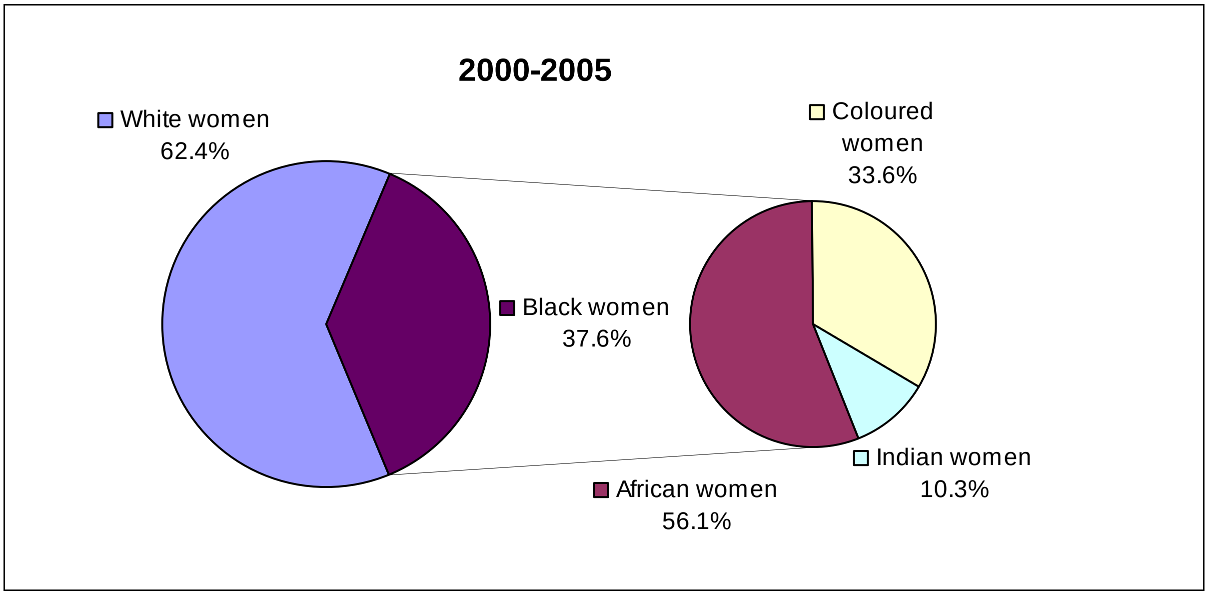


Source: Quantec, 2007 (StatsSA OHS data for 1996 – 1999; StatsSA LFS data for 2000 – 2005)

We have shown that the real numbers of female CPAPs declined between the two periods. Furthermore, the white female share of employment increased slightly over the period. Notwithstanding this broad picture, African females improved their share of employment within the category of black female professionals and associate professionals from 47.4 per cent to 56.1 per cent over the period (Figure 10). There was a corresponding decrease in the employment share of coloured and Indian females.

Figure 10: Women CPAPs, 1996 to 2005





Source: Quantec, 2007 (StatsSA OHS data for 1996 – 1999; StatsSA LFS data for 2000 – 2005)

Distribution of computer professionals and associate professionals by age

The distribution of CPAPs according to age is an important parameter to bring into the reckoning from a labour market supply and demand perspective. Analysis according to age intervals will reveal disproportions in the distribution of the workforce per age category. For example an over-large proportion of older workers or an over-large proportion of young workers will each present management and supply-demand challenges. If the data permits, analysis by age can be extended to demographic groups (eg: race or gender) per age group, which will reveal the impact of equity legislation on employment patterns.

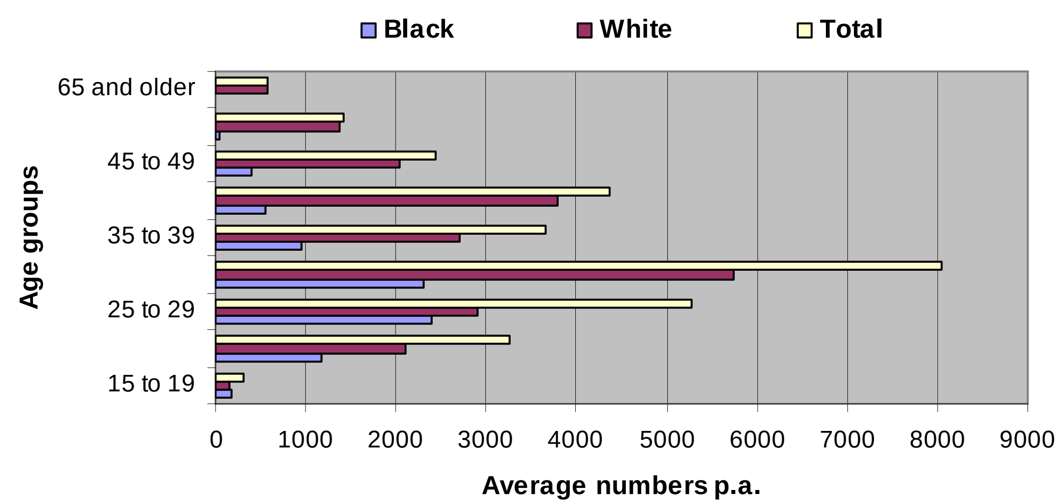
We will firstly compare the age distributions of high skill computer professionals and intermediate skill associate computer professionals. The proportion of young computer professionals up to and including age 29 at 30.2 per cent is lower than the proportion of computer associate professionals of the same age range which is 39.4 per cent. Both occupational groups have a very similar ratio in the age group 30 to 39 years of nearly 30 per cent. The two occupational categories differ substantially in the proportion of workers in the upper age range 40 years and older. The upper age range constitutes 36.5 percent of computer professionals, and 20.9 percent of computer associate professionals.

The population distribution of computer associate professionals appears far more healthy than that of the computer professionals. Even taking into account that computer professionals will take longer to acquire their qualifications (eg: 3-5 years) and that the peak at which they begin working will be later than for computer associate professionals who will on balance have shorter qualification duration and begin work earlier. The proportion employed which is younger than 30 is much smaller than for computer associate professionals.

Disaggregating the workforce in each occupational group by age range and race, provides a perspective on how far equitable access has extended. Among the associate computer professionals, in the age group up to 29 years, 40.2 per cent were black and 38.6 per cent white, while among workers aged 40 and above 25.2 per cent were black and 20.9 per cent white. The age proportions within each group are relatively similar. Among computer professionals in the age group up to 29 years 46.7 per cent were black and 24.1 per cent white, while among workers aged 40 and above 12.6 per cent were black and 36.5 per cent white (Figure 11).

Very apparent in the associate computer professionals is stability in the distribution of numbers across the age groups spanning 20 to 39 years (20-25, 25-29, 30-34 and 35-39). In each of these age categories, on average numbers exceeded 5000. By contrast, among computer professionals, the distribution by age group was very uneven with a single peak of 8000 in the 30-34 age category.

Figure 11: Average number of Computer professionals p.a. by age and race, 2000 to 2005 change graphs?



Race	Age group								
	15 - 19	20 - 24	25 - 29	30 - 34	35 - 39	40 - 44	45 - 49	50 - 64	65 and older	Total
Black	2.1	14.7	29.9	28.8	11.9	7.0	5.0	0.6	0	100
White	0.7	9.8	13.6	26.9	12.7	17.8	9.5	6.5	2.7	100
Total	1.1	11.1	18.0	27.4	12.5	14.8	8.3	4.9	2.0	100

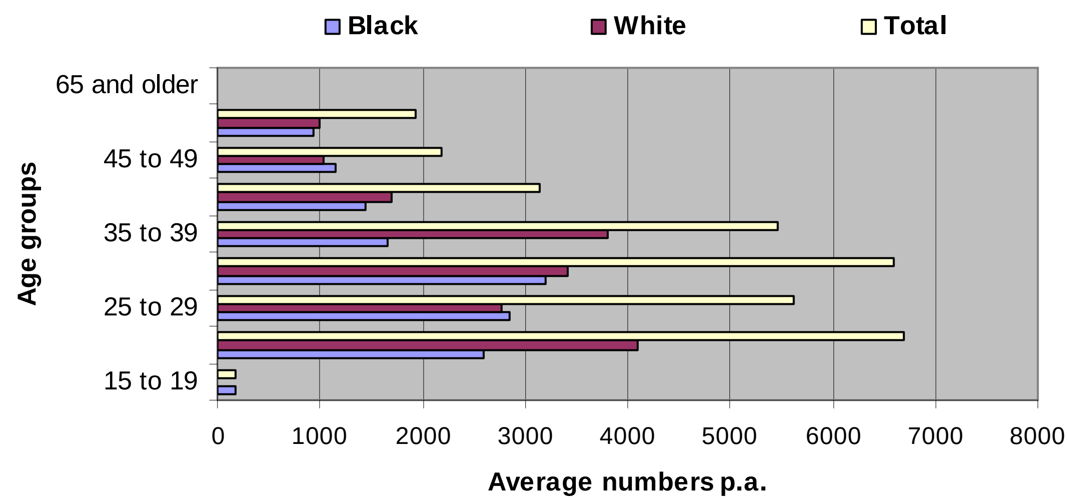
Source: Quantec, 2007 (StatsSA OHS data for 1996 – 1999; StatsSA LFS data for 2000 – 2005)

Computer associate professionals are even younger than computer professionals, as shown in Figure 12. Most (21.1 per cent) computer associate professionals were in the age group 20 to 24 over the 2000-2005 period. Almost half (23.0 per cent) of the white computer associate professionals were in this young age group over this period.

Conversely, 22.8 per cent of black computer associate professionals were in the older 30 to 34 age group over the same period.

Transformation has thus occurred to a greater extent among computer associate professionals than among computer professionals, as there were quite a number of black computer associate professionals in both the lower as well as higher age cohorts and this trend will continue in future, as almost two thirds of black computer associate professionals are younger than 35 years of age, while 42.3 per cent of the white computer associate professionals are older than 35.

Figure 12: Average number of Computer associate professionals p.a. by age and race, 2000 to 2005



Race	Age group								
	15 - 19	**20 - 24**	**25 - 29**	**30 - 34**	**35 - 39**	**40 - 44**	**45 - 49**	**50 - 64**	**65 and older**	**Total**
Black	1.3	18.6	20.3	22.8	11.9	10.3	8.2	6.7	0	100
White	0	23.0	15.6	19.1	21.4	9.5	5.8	5.6	0	100
Total	0.6	21.1	17.7	20.7	17.2	9.9	6.8	6.1	0	100

Source: Quantec, 2007 (StatsSA OHS data for 1996 – 1999; StatsSA LFS data for 2000 – 2005)

PART TWO

Supply

There are various routes of 'supply' of skilled workers into a national occupational labour market (eg: graduates from education institutions and service providers, in-service training, in-migration etc.). The South African labour market for ICT professionals is certainly no exception.

The main contributor to ICT skilling in terms of volume and variety of learning opportunities is the private sector. It is estimated that around three-quarters of ICT workers hold post-school qualifications from private training service providers. Private training providers offer courseware to meet various needs including: for those who do not qualify for university or university of technology training; for those who cannot afford higher education fees; for those who can study only part time; for those who require product or application-specific training, or who wish to upgrade or broaden their skills in particular ICT sub-fields; and also for enterprises seeking training specific to their unique in-house software environments.

Most private sector training courses available on the market is of short duration, is focused on particular IT implementation environments, and strongly emphasises practice rather than theory.[2] Consequently, a very small proportion of learning opportunities at private ICT training institutions could be said to be equivalent to a higher education qualification such as an undergraduate degree which provides a coherent programme of learning at high-skills level with a strong theoretical base.

In the analysis that follows, we will therefore address the contribution of South African higher education institutions to the supply of ICT professionals.[3]

Enrolment

It is important to begin by considering student enrolment parameters, because changes in enrolment reflect changes in enthusiasm for taking up ICT higher education based occupational training among prospective students, among potential new entrants to the ICT labour market and also among the currently employed. The size of higher education enrolments in any given year is an important parameter which sets the upper limits on the potential number of persons who could graduate with ICT qualifications.

[2] The ISETT SETA is registering IT training providers that seek NQF and Department of Labour/SETA accreditation or that seek accreditation of their courseware. The ISETT SETA website lists 30 accredited private training providers. An extensive list of providers is provisionally accredited and approved. However international software and training vendors with their own global qualification systems will probably not see the necessity to submit to local accreditation. As a result their training numbers will remain unknown.

[3] Some ICT training is undertaken in the Further Education and Training (FET) colleges. In some instances training is provided in the form of International Computer Driver's License (ICDL) or similar types of courseware. These courses are only offered by some institutions. National Department of Education information is provideded per instructional offering (ie: per course) and not per whole qualification completed. Therefore FET graduates who hold a qualification which includes some form of intermediate-level ICT course cannot be counted. NDoE data is not provided by race or gender. Refer to appendix for ICT output data at FET colleges.

Data on enrolment for computer science and data processing was obtained from the Department of Education's Higher Education Management Information System (HEMIS) with fields of study classified according to the Classification of Educational Study Matter (CESM). This database has data on all enrolment and graduates from universities and universities of technology.

'Computer Science and data processing' is the broad category that refers to a number of sub-study field categories. In HEMIS the CESM (0600) for computer science and data processing refers to the aggregation of applications in computer science and data processing (0601); computer operations and operations control (0602); computer hardware systems (0603); computer hardware (0604); information and data base systems (0605); numerical computations (0606); programming languages (0607); programming systems (0608); software methodology (0609); theory of computation (0610); education, societal and cultural considerations (0611); and other computer science and data processing (0699).

Before 1999 enrolment and graduate numbers were not disaggregated into the various sub-study fields of computer science and data processing (CESM 0600). Only since 1999 were enrolment and graduate numbers given according to the various sub-study fields (CESM 0601 – 0611).

Enrolment in computer science and data processing 1996-2005

Enrolments at universities and universities of technology in the study field of computer science and data processing rose steadily over the period 1996 to 2005. This amounted to an average annual increase of 1.9 per cent in certificate/diploma enrolments, 6.2 per cent in degree enrolments, and a 6.8 per cent increase in postgraduate enrolments, as indicated in Table 12.

The proportions of black candidates enrolling for certificate or diploma qualifications in the field of computer science and data processing increased over the period, as measured in annual average growth. Starting with certificate/diploma courses, black female enrolment (6.5 per cent) and black male enrolment increased (5.8 per cent) over the period, whereas there was negative growth in the enrolment of white males (-11.6 per cent) and females (-14.2 percent)

A similar pattern was evident for degree courses in the computer science and data processing study field where the share of enrolments among black men (12.7 per cent) and women (12.9 per cent) over this period increased, while enrolments of white males and females decreased. In real terms, this means that both black male and black female enrolment tripled in size between 1996 and 2005. White male enrolment numbers dropped over the period at a rate of -5.1 per cent and white female enrolment declined quite sharply at a rate of -9.2 per cent.

Postgraduate enrolments grew off a small base. Measured in annual average growth, there was a substantial rise of 19.2 per cent and 12.8 per cent in black female and male postgraduate enrolments respectively, while white male enrolments rose 4.5 per cent over the period, while white female enrolment declined in annual average and real terms.

Table 12: Enrolment in computer science and data processing by race group and gender, 1996-2005

Qualification	Race	Gender	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Average annual growth (1996 - 2005)
Certificate /	Black	Men	1535	2236	2947	3658	3322	2093	1936	2341	2330	2544	5.8
Diploma		Women	1101	1684	2463	3243	3089	1523	1551	2076	1858	1934	6.5
	White	Men	1122	1101	990	880	664	394	443	407	341	370	-11.6
		Women	431	399	415	430	326	142	175	126	120	109	-14.2
	Un-	Men	0	0	0	22	0	1	1	1	0	0	0.0
	known	Women	0	0	0	24	0	1	0	1	1	0	0.0
	Total		4188	5420	6815	8257	7401	4154	4105	4952	4650	4957	1.9
Degree	Black	Men	396	429	523	616	1404	1916	1988	1884	1180	1164	12.7
		Women	238	344	439	534	1112	1454	1350	1240	758	708	12.9
	White	Men	543	620	589	558	759	944	1072	958	678	511	-0.7
		Women	286	300	299	297	278	344	351	257	167	120	-9.2
	Un-	Men	0	0	0	1	0	1	0	2	5	4	0.0
	known	Women	0	0	0	0	0	0	0	1	1	3	0.0
	Total		1464	1694	1850	2006	3553	4657	4761	4342	2790	2509	6.2
Post-	Black	Men	62	94	82	69	77	109	159	234	201	185	12.8
graduates		Women	21	55	52	49	37	58	79	123	104	104	19.2
	White	Men	184	184	164	145	128	217	298	324	264	273	4.5
		Women	73	57	52	47	48	81	100	113	80	55	-3.1
	Un-	Men	0	0	0	0	0	0	0	3	0	0	0.0
	known	Women	0	0	0	0	0	0	0	0	0	0	0.0
	Total		341	390	350	311	289	464	636	798	648	618	6.8
Total	Black	Men	1993	2760	3552	4344	4803	4118	4083	4459	3711	3893	7.7
		Women	1360	2083	2954	3825	4238	3035	2980	3439	2720	2746	8.1
	White	Men	1850	1905	1744	1583	1551	1554	1813	1689	1282	1153	-5.1
		Women	789	756	765	774	652	566	626	496	367	284	-10.7
	Un-	Men	0	0	0	23	0	2	1	6	5	4	0.0
	known	Women	0	0	0	24	0	1	0	2	2	3	0.0
	Total		5993	7504	9015	10573	11243	9275	9502	10092	8088	8083	3.4

Source: DoE (1996 – 2005)

Enrolment share for 2005 by race and gender

If we look more closely at the recent 2005 patterns of enrolment by race group (Table 13) at the different qualification levels, the following pattern emerges: black candidates dominate enrolment at diploma/certificate level (90.3 per cent) and to a slightly lesser extent at the degree level (74.6 percent) while white candidates constitute the majority of enrolment at the post-graduate level which is dominated by white males. The share of black enrolments decreases as the level of qualification rises. This can be ascribed to the relatively poor background in mathematics and science subjects that many black students experience at school and they may not then qualify to enter certain academic programmes. Decreasing black student enrolment at higher levels of qualification, can be attributed the attraction to enter the labour market immediately upon completion of the initial qualification or to difficulties in completing the study programme because of lack of funding, disadvantaged school background or insufficient academic support.

We need to investigate further the position of very substantial numbers of diploma and certificate students, who are mostly black. By establishing the academic background of students, whether they are enrolled on a part-time or a full time basis, what the curriculum of such programmes is, what the vocational-theory balance of such diploma/certificate programmes are, will assist us in assessing the contribution of such qualifications to broadening the ICT skills base and to equity of access to the workplace.

Table 13: Proportionate share of enrolment by qualification level, race and gender, 2005

	Diplomas and certificates		Degrees		Post-graduate degrees	
	N	%	N	%	N	%
Black Male	2544	51.3	1164	46.4	185	29.9
Black Female	1934	39	708	28.2	104	16.8
White Male	370	7.5	511	20.4	273	44.2
White Female	109	2.2	120	4.8	55	8.9
Unclassified	0	0	4	0.2	0	0
Unclassified	0	0	3	0.1	0	0
Total	4957	100	2509	100	618	100

Source: DoE (1996 – 2005)

In the sections that follow, we examine graduate production from higher education.

Graduates

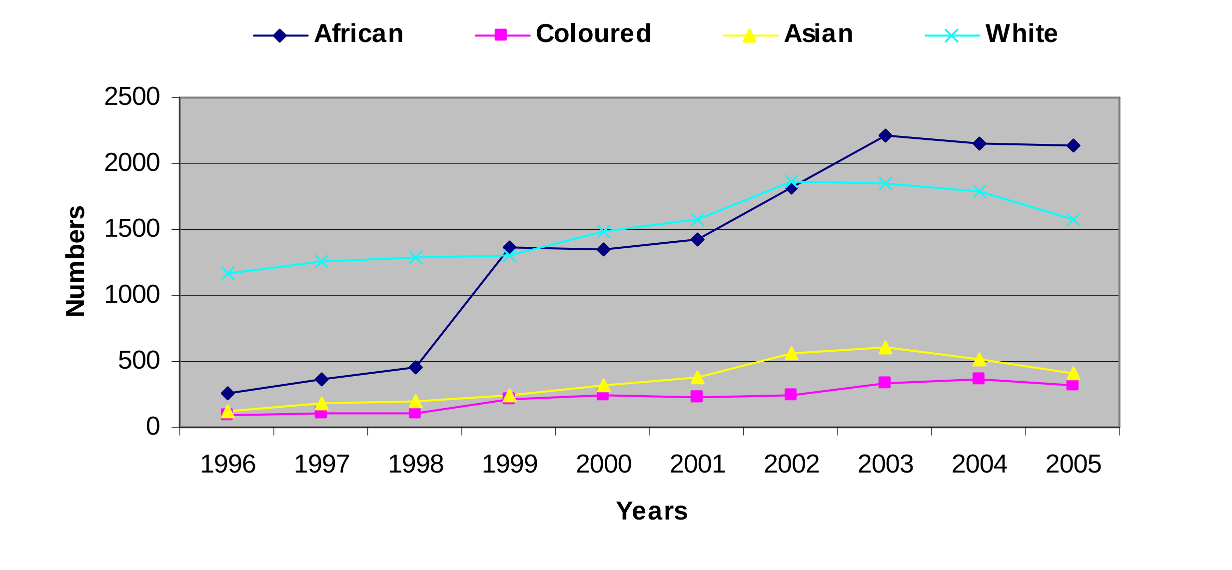
Graduates from Computer Science and Data processing 1996 to 2005

Over the period 1996 to 2005 the number of computer science and data processing graduates grew substantially (Figure 13). In real terms, graduate output rose from 1 645 in 1996 to 4 449 in 2005, yielding an annual average increase of 11.7 per cent.

Within this overall increase, growth in graduate output by race group was uneven. The highest growth rate was visible for African graduates with an average annual growth of 26.5 per cent. Coloured and Indian graduate production in computer science and data processing obtained average annual growth of 15.5 and 14.0 per cent respectively. White graduate production experienced the lowest average annual increase at 3.3 per cent.

Clearly, the main locus of growth was with African graduates whose numbers significantly exceeded white graduates for the first time in 2003. The share of white graduates peaked in 2002 and declined over the ensuing years. In effect, African graduate production increased sevenfold, whereas white graduate production increased by 34.4 per cent over the decade.

Figure 13: Output at HE institutions in computer science and data processing by race, 1996 to 2005



Race	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Average annual growth (1996-2005)
African	259	357	457	1368	1348	1423	1822	2210	2158	2143	26.5
Coloured	86	106	108	215	240	227	235	327	362	316	15.6
Asian	128	189	191	239	312	374	559	605	514	415	14.0
White	1172	1263	1293	1300	1488	1574	1863	1841	1794	1575	3.3
Total	1645	1915	2049	3122	3388	3598	4479	4983	4828	4449	11.7

Source: DoE (1996 – 2005)

Graduates by qualification level and race

This section examines graduates by qualification level and race, two important dimensions according to which we need to monitor change. In the period under consideration, a double shift occurred: degree'd graduate numbers increased over certificate/diploma graduate numbers, and black graduate numbers increased over white graduate numbers.

First in terms of the share of graduates by race, in 1996 white graduates held the majority share of graduates at all three qualification levels in computer science and data processing, as shown in Table 14 and in Figure 14. By 2005 this situation had shifted considerably. Black graduates increased their share of certificate/diploma qualifications by more than ten percent and their share of degree qualifications by more than twenty percent in the decade. As a result black graduate were in the majority at the certificate/diploma level and at the degree level, while at the postgraduate level in 2005 white graduates proportions were still a slim majority.

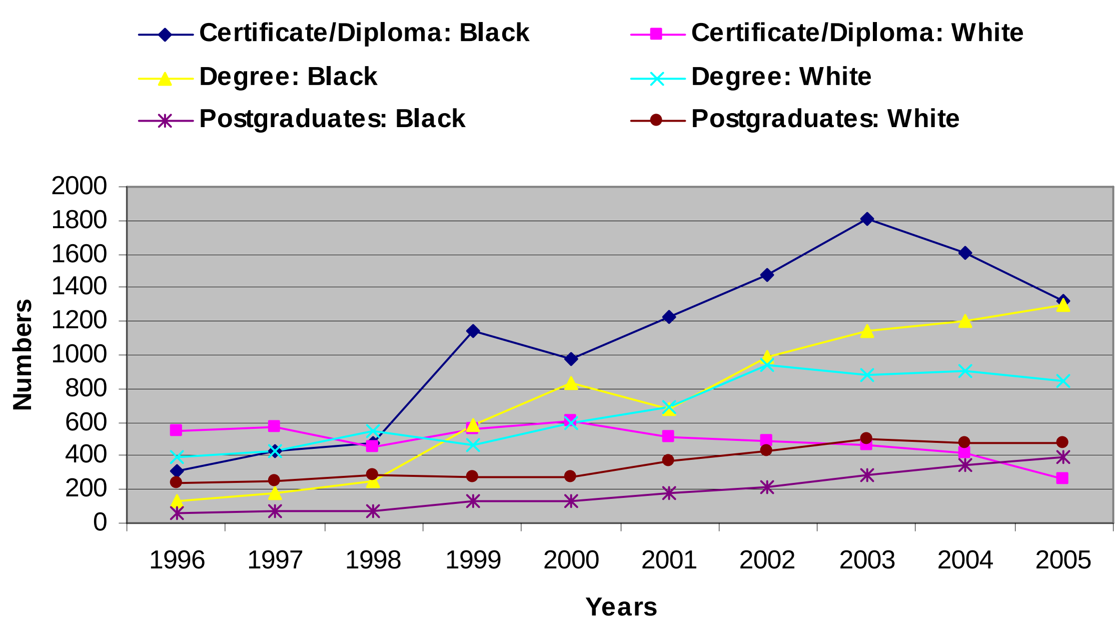
Second, in the same period changes occurred in the overall distribution of graduates between qualification levels. Graduates holding certificates and diplomas as a proportion of all graduates declined from 51 per cent to 34.5 per cent while the share of graduates with degrees increased from 30.8 per cent to 46.6 per cent between 1996 and 2005. Postgraduates as a share of all graduates held the same proportion. This means that there was an increase in the overall qualification levels per cohort over the period that was available to the labour market.

Table 14: Proportionate share of graduate numbers by qualification level and race, 1996 and 2005

	1996		2005	
	N	%	N	%
Certificate/Diploma: Black	310	18.5	1324	28.9
Certificate/Diploma: White	544	32.5	256	5.6
Degree: Black	127	7.6	1293	28.2
Degree: White	389	23.2	846	18.4
Postgraduates: Black	65	3.9	398	8.7
Postgraduates: White	239	14.3	472	10.3
	1674		4589	

Source: DoE (1996 – 2005)

Figure 14: Graduation trends by qualification level and race, 1996 to 2005



Qualification by race	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Average annual growth (1996-2005)
Certificate/Diploma: Black	310	427	472	1142	977	1224	1480	1807	1613	1324	17.5
Certificate/Diploma: White	544	576	458	563	612	506	493	459	415	256	-8.0
Degree: Black	127	183	249	583	832	674	985	1139	1198	1293	29.4
Degree: White	389	434	545	469	601	694	945	878	900	846	9.0
Postgraduates: Black	65	68	70	129	133	179	218	291	346	398	22.3
Postgraduates: White	239	252	290	268	276	374	425	505	479	472	7.8

Source: DoE (1996 – 2005)

Graduates by gender

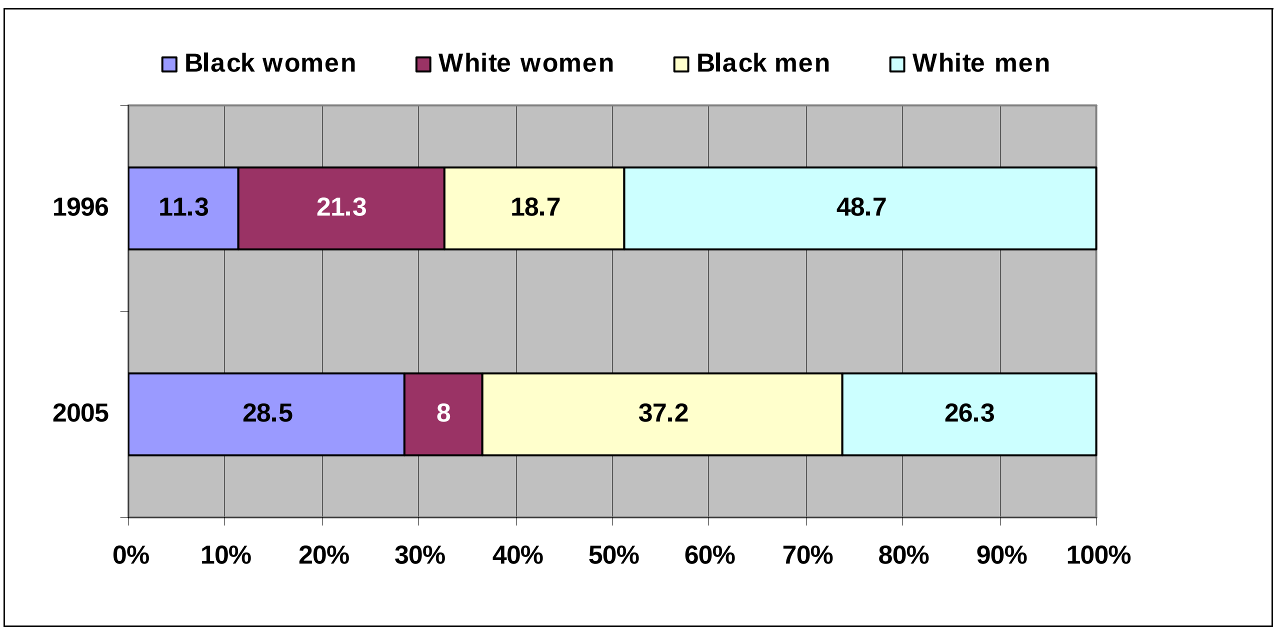
The ratio of computer science and data processing graduates by gender has marginally increased in favour of females from 32.5 to 36.5 per cent between 1996 and 2005. This means that the gender make-up of computer graduates has hardly shifted in the decade (Figure 15).

However, the same cannot be said of the race share within male graduates and within female graduates. Black men and women increased their share of graduates considerably.

Black woman graduates increased at an average annual growth of 24.0 per cent, whereas their white contemporaries experienced an average annual growth of only 0.3 per cent. Similarly, black male graduates increased at an average annual growth of 20.7 per cent whereas white male graduates increased at an average annual growth of only 4.5 per cent.

As a consequence of these changes, by 2005 the number of black female graduates with computer science and data processing across all qualification levels was greater than the number of white male graduates.

Figure 15: Graduates in computer science and data processing by race and gender, 1996 and 2005



Source: DoE (1996 – 2005)

Graduates by qualification level and gender

We reported that the female share of computer science and data processing graduates increased slightly over the period 1996 to 2005. The average annual number of female graduates increased slightly more than the number of male graduates at all three qualification levels: 13.2 against 12.1 per cent at the postgraduate level 18.1 against 16.7 per cent at the undergraduate degree qualifications, and 9.8 against 5.3 per cent at the certificate/diploma level.

It is noticeable that the proportion of male holders of certificate/diplomas declined significantly in relation to all other qualifications between 1996 and 2005 whereas this was not as evident for females. This proportion must be monitored lest increases in the number of female graduates become concentrated among lower qualification levels (Table 15).

Table 15: Proportionate share of graduate numbers by qualification level and gender, 1996 and 2005

	1996		2005		Average annual growth (1996-2005)
	N	%	N	%	
Certificate/Diploma: Women	296	17.7	688	15.0	9.8
Certificate/Diploma: Men	558	33.3	891	19.4	5.3
Degree: Women	162	9.7	725	15.8	18.1
Degree: Men	354	21.1	1421	30.9	16.7
Postgraduates: Women	86	5.1	262	5.7	13.2
Postgraduates: Men	218	13.0	610	13.3	12.1
Total	1675	100	4598	100	11.9

Source: DoE (1996 and 2005)

Graduates share between sub-fields of computer science and data processing, 1999 and 2005

In this section we explore changes in graduate production across the computer science and data processing sub-fields in two ways. First we examine changes in the share of graduate production across sub-fields between 1999 and 2005. Thereafter, we compare the various sub-fields according their average annual growth over the same period. We have indicated that only after 1999 were graduates sub-specified according to the various sub-study fields (CESM 0601 – 0611) within the broader category of computer science and data processing.

A snapshot of graduate numbers per sub-field in 2005 reveals that only a few are responsible for a major share of graduate production (Table 16). The major four contributors are: information and database systems (36. 0 per cent), applications in computer science and data processing (21 per cent), computer operations and operations control (9.2 per cent) and programming languages (8.8 per cent). Together these study fields contribute 75 per cent of all graduates in the computer science and data processing fields.

Yet only two, 'Information and database systems' and 'computer operations and operations control' increased their share of graduates between 1999 and 2005, the former increased by a sizeable margin of just over ten percent. In contrast, two of the top four fields suffered declining output: applications in computer science and data processing (-4.2 per cent) and programming languages (-3.9 per cent).

The question is why these patterns emerged and to what extent the shifts in graduate numbers between the sub-fields resolve or aggravate labour market demand?

Table 16: Share of graduate production among fields of specialisation in computer science and data processing, 1999 and 2005

	1999		2005	
	N	**%**	**N**	**%**
Computer Hardware Systems	60	1.8	179	3.9
Programming Systems	115	3.5	296	6.4
Computer Ops & Operations Control	196	6.0	422	9.2
Information & Data Base Systems	845	25.8	1656	36.0
Applications in Computer Sc & Data Processing	825	25.2	967	21.0
Education, Societal & Cultural Considerations	63	1.9	67	1.5
Programming Languages	417	12.7	404	8.8
Other Computer Science & Data Processing	577	17.6	554	12.1
Software Methodology	49	1.5	45	1.0
Computer Hardware	15	0.5	1	0.0
Theory of Computation	26	0.8	2	0.0
Numerical Computations	83	2.5	4	0.1
Total	3271	100	4597	100

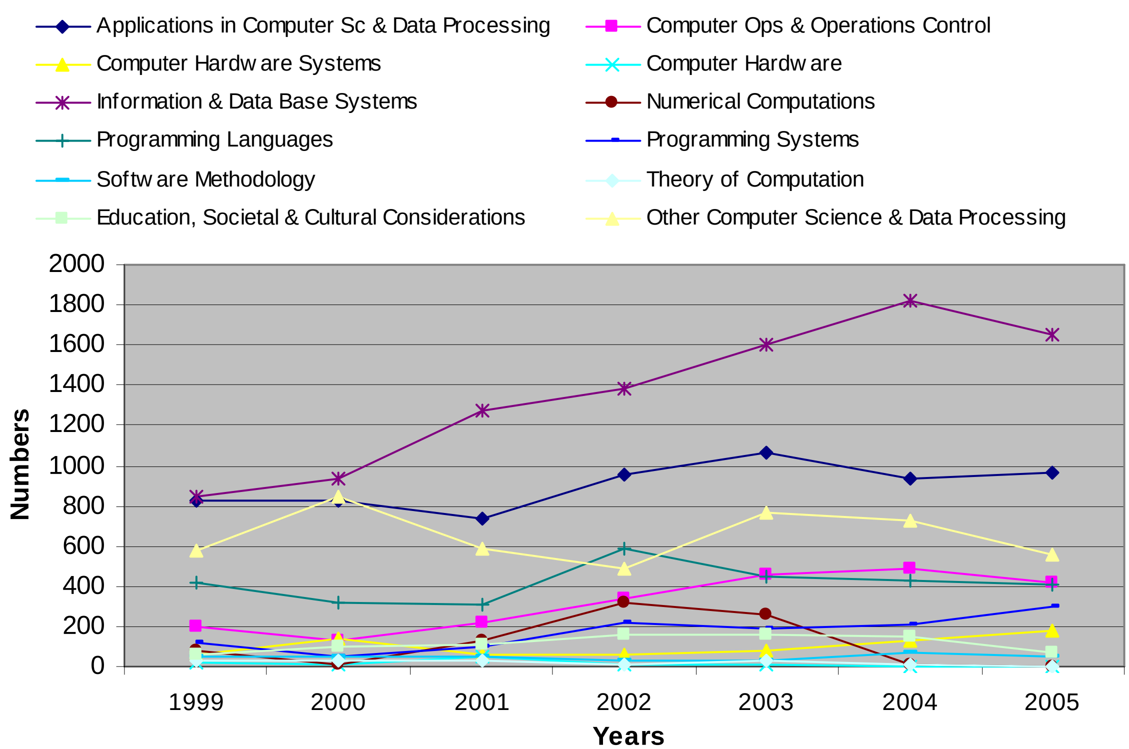
Source: DoE (1996 and 2005)

Average annual growth in computer science and data processing sub-fields

To obtain an overview of changes in graduate output, annual average growth was calculated for all of the sub fields over the period (Figure 16). It is interesting that three of the smaller sub fields showed strongest growth: computer hardware systems, programming systems and computer operations and operations control reflected average annual growth in graduate output of 20.0 per cent, 17.1 per cent, and 13.7 per cent respectively. Notwithstanding its already large share, annual average growth of information and data base systems graduates increased 11.9 per cent.

The number of graduates in programming languages, other computer science and data processing, software methodology, computer hardware, theory of computation, and numerical computations showed negative growth over the seven years. Further research into the factors driving these processes is worth undertaking.

Figure 16: Graduates in various computer science and data processing fields of specialisation, 2005



Fields of specialisation in computer science and data processing	1999	2000	2001	2002	2003	2004	2005	Average annual growth (1999-2005)
Computer Hardware Systems	60	142	56	58	79	130	179	20
Programming Systems	115	48	98	214	185	209	296	17.1
Computer Ops & Operations Control	196	127	215	343	459	486	422	13.7
Information & Data Base Systems	845	933	1271	1379	1602	1823	1656	11.9
Applications in Computer Sc & Data Processing	825	821	741	956	1063	936	967	2.7
Education, Societal & Cultural Considerations	63	99	114	164	162	150	67	1.2
Programming Languages	417	321	313	588	445	428	404	-0.5
Other Computer Science & Data Processing	577	850	586	484	765	727	554	-0.7
Software Methodology	49	51	51	27	26	68	45	-1.3
Computer Hardware	15	12	48	5	7	0	1	-36
Theory of Computation	26	27	29	7	30	12	2	-37.7
Numerical Computations	83	6	134	321	256	7	4	-39.9

Source: DoE (1999 – 2005)

Graduates in fields cognate to ICT

The dynamics of labour demand and labour supply in the field of ICT, are quite complex. On the one hand, the fields of knowledge, and the kinds of qualifications involving ICT that are offered in higher education are overlapping and quite diverse. On the other hand, the job opportunities encompassed by the term ICT are also diverse and overlapping. Consequently, the kind of one-to-one relationship between a qualification and an occupation that might be expected, such as in certain professions (eg: between a teaching degree and a teaching post or between a medical doctor's degree and a general practitioners post) cannot be as easily assumed for the IT field.

The reasons for this include: rapid uptake of ICT across a range of different occupations and fields (eg: graphic arts and design), applicability of 'pure' disciplines such as mathematics to ICT (eg: operations research); convergence of fields such as 'computer science' and 'computer engineering'. The complex dynamics behind these processes cannot be unpacked here, the main point being that there is not a direct relationship, for example, between the production of graduates from computer science, and the existence of a particular set of job opportunities only for people with a computer science qualification.

An additional factor that contributes to an imprecise relationship between qualifications and job vacancies is substitution. This occurs where a worker with particular qualifications that qualify her for an occupation may - with industry experience and/or short term industry training – successfully occupy a different occupation. The phenomenon of transferability or mobility of workers between occupations cannot be ruled out in the broad field of ICT.

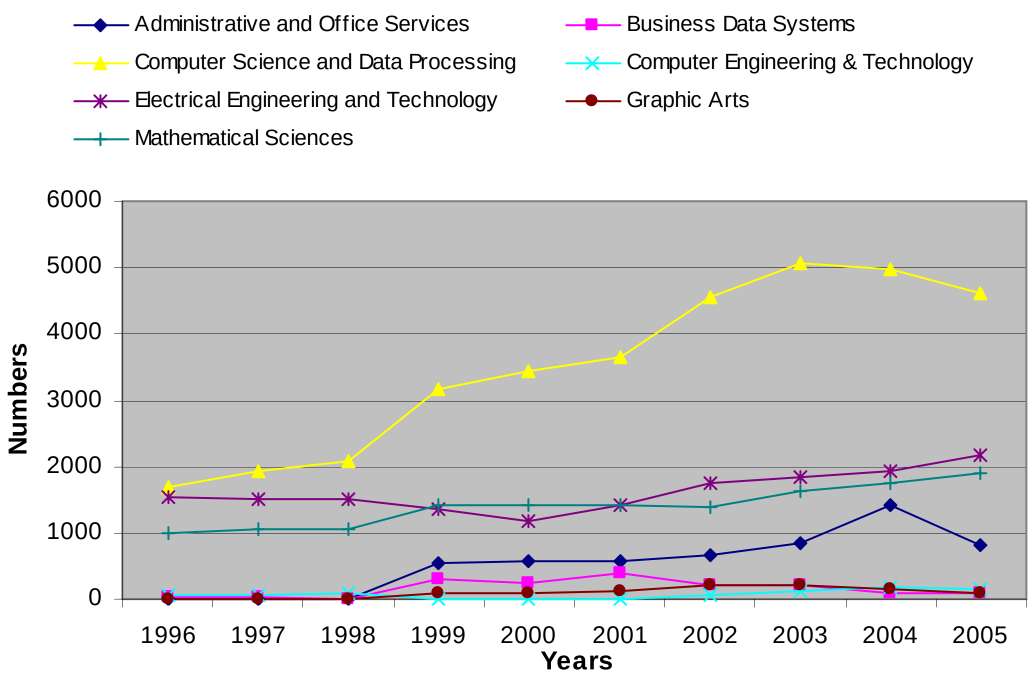
Thus, to properly understand the broad context of demand and supply among ICT related occupations, it is necessary to refer to a range of qualifications from study fields that are cognate to computer science that may contribute to supply. Therefore, we have identified several cognate fields of higher education study which will contribute to the overall production of high skills ICT workers. We suggest that changes in the graduate outputs from these study fields could impact on the overall situation regarding demand and supply of high level ICT skilled workers.

As shown in Figure 17, the number of graduates from the computer engineering and technology study field had an average annual growth of 14.3 per cent, off a low base of 47 graduates in 1996. Similarly, graduates in business data systems grew at 12.6 per cent per annum off a low base of 36 graduates.

In the same period, mathematical science graduates grew annually at 7.3 per cent, while those in electrical engineering and technology grew at 3.8 per cent over the period. For the newer fields such as 'graphic arts' and 'administrative and office services' since 1999 the average annual growth for these two fields of study was 0.4 per cent and 7.0 per cent respectively.

Although the graduate output from these study fields is smaller than that of computer science and data processing, we cannot exclude them from the broader picture of graduate output that could contribute in some measure to the need for skills in the IT field.

Figure 17: Graduates in ICT-cognate fields of study, 1996 to 2005



ICT related fields of study	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Average annual growth (1996-2005)
Administrative & Office Services	0	0	0	531	572	576	660	858	1431	799	7.0
Business Data Systems	36	35	11	291	227	377	220	208	83	104	12.6
Computer Science & Data Processing	1675	1941	2083	3160	3437	3655	4546	5078	4976	4598	11.9
Computer Engineering & Technology	47	48	102	3	15	13	60	111	180	156	14.3
Electrical Engineering & Technology	1543	1493	1508	1367	1182	1404	1755	1826	1930	2156	3.8
Graphic Arts	0	0	0	87	84	124	215	216	139	89	0.4
Mathematical Sciences	1010	1067	1047	1430	1423	1425	1394	1616	1762	1902	7.3

Source: DoE (1996 – 2005)

Graduates by qualification level in ICT-cognate fields of study, 2005

We have argued above that it is necessary to take into account the graduate output of ICT-cognate fields of study. In order to obtain a more complete picture of the possible contribution from these fields, we must consider graduate output by qualification level.

This procedure helps to provide a more realistic take on the possible contribution of graduates from study fields other than computer science and data processing. For instance the field of 'computer engineering and technology' does not include diplomas and certificates and for this reason can be considered a generally high-skilled group. In contrast, the graduates of 'electrical engineering and technology' and 'administrative and office services' are dominated by certificates and diplomas which implies that their contribution to high level skills is proportionately delimited (Table 17).

Table 17: Graduates by qualification level in ICT cognate fields of study in percentages, 2005

	Certificate / Diploma	Degree	Postgraduates	Total
Computer Science and Data Processing	36.9	46.7	16.4	100
Computer Engineering & Technology		74.6	25.4	100
Electrical Engineering and Technology	54.7	33.3	12.1	100
Mathematical Sciences	9.0	60.3	30.7	100
Business Data Systems		31.6	68.4	100
Administrative and Office Services	83.9	15.4	0.8	100
Graphic Arts	41.9	58.1		100

Source: DoE (2005)

What the above analysis tells us is that, other than computer science and data processing, the fields such as Business Data Systems and Computer Engineering and Technology may indeed contribute considerably though unevenly to the output of ICT field related graduates into the labour market. However at this stage, we cannot know how this graduate production impacts on employment and skills shortages.

PART THREE

Supply and demand for ICT Graduates

Thusfar in the first part of our analysis, we have paid considerable attention to the features of the CPAP workforce – the so-called ‘demand side’ of the supply-demand relationship. In the course of the analysis we have been able to make limited inferences about possible shortages of computer professionals. Some of these aspects will be revisited in the conclusion of this paper.

In the second part of the analysis, we presented an analytic overview of graduate production from higher education in the fields of study which are considered to be the main source of qualified computer professionals outside of the private ICT training industry. Analysis of the contribution of private training was not within the brief of this work.

So far we have not explicitly addressed how demand for computer professionals in the labour market and supply of qualified graduates in computer science and related field interact. In this section of the analysis we attempt to add value to the debate about computer professionals in the labour market in three ways.

In the first two instances we refer to information from the labour market itself in order to approach the question of demand and supply of computer professionals. In one scenario we use *data from a survey of vacancies* to draw some tentative hypotheses about labour shortages in the computer professional occupational fields.

In the other scenario, we apply standard economic theory to an analysis of *data on the remuneration* of professionals and of computer professionals in South Africa. In so doing we observe that changes in remuneration of computer professionals is evidence of a labour shortage in these occupations.

Finally, we attempt to bring together the data that we have assembled and analysed in the first two parts of this paper. In doing this, we will attempt to *bring the demand and supply sides together so to speak to make a projection*. We use data on the size and on other dimensions of the computer professional occupational labour market to generate assumptions about future behaviour of the market in those occupations. We then create a model that projects possible demand into the future. A similar approach is applied on the supply side which involves generating a predicted graduate output curve into the future. The curves of demand and supply are then juxtaposed so that a putative shortage/oversupply figure is produced.

We then conclude this section with a discussion on the relative value of the results from each approach to understanding the demand-supply conundrum.

Vacancies for Information and Communication Technology professionals

Research indicates that employment data such as counts of vacancies per occupational category can be evaluated to assess the existence of or the potential for a skills shortage (Veneri 1999, Lopez-Bassols 2002). Such information is not available from the LFS or the OHS, so additional research must be conducted on the matter either among employers or in the media which carry job advertisements, or among labour brokers or other service businesses in the recruitment field.

The vacancy data reported on below was drawn from a national weekly Sunday newspaper (Sunday Times) over three years between April 2004 and March 2007. The key information about each job advertised was coded occupationally and entered into a database created by the Department of Labour (named the 'Job Opportunity Index database) which was then analysed by the HSRC (Erasmus 2007).

Before undertaking the analysis, some reservations about the data must be recorded. Employers advertise vacant posts in different media (eg: the ICT industry advertises vacant posts quite extensively through the internet) so the data recorded does not provide a full picture of all advertising. The data also does not account for other channels of recruitment such as head hunting. Therefore, the data acquired will not necessarily reflect the full extent of vacancies in the ICT sector.

According to vacancies as advertised in Career Junction (2008) over three years (2005 to 2007), almost a quarter (24.5 per cent) of vacancies were for ICT workers, 20.1 per cent for financial positions, 8.4 per cent for engineering positions and lower percentages for vacancies in other positions which is an indication of a demand for ICT workers.

Vacancy data analysis

From vacancy data captured across the period, 2 499 vacancies were classified as belonging to the sub-major occupational group 26: ICT (Information and Communication Technology) Professionals.[4]

Vacancies for ICT Professionals accounted for 4.4 per cent of all vacancies for professionals over the three years under review (Table 18). According to current employment, 5.1 per cent of all professionals are computer professionals. A 4.4 per cent vacancy rate for computer professionals among all professionals according to our survey of vacancies could indicate that a shortage in computer professionals is experienced.

Compared to computer associate professionals it seems as if there is more of a shortage of computer associate professionals than for computer professionals, as a 9.7 per cent of vacancies for all associate professionals were for computer associate professionals according to our survey of vacancies, while according to current employment, only 1.2 per cent of all associate professionals are computer professionals. The demand for computer associate professionals is thus higher than the current employment in proportion to other associate professionals.

According to our survey of vacancies, there does not seem to be such a high demand for ICT managers as for computer professionals and associate professionals. Only 1.2 of all managerial vacancies was for ICT management vacancies, while 14.3 per cent of all managers that are currently employed, are ICT managers. It must, however, been kept in mind that ICT managers are usually head hunted.

[4] using the OFO system.

The largest share of job vacancy adverts were placed in search for Business and Systems Analysts and Programmers (61.5 per cent), followed by vacancies for ICT Network and Support Professionals (23.2 per cent). Database and Systems Administrators, and ICT Security Specialists accounted for 15.3 per cent of all ICT Professional vacancies.

Table 18: Share of vacancies for ICT Professionals by OFO Occupational Group , and by year in percentages

OFO Occupational Group	Share of vacancies			
	04/05	05/06	06/07	3 year average
ICT Professional vacancies as a share of total vacancies recorded[1]	3.69	4.74	4.53	4.4
261 Business and Systems Analysts and Programmers	57.4	60.2	64.8	61.5
262 Database and Systems Administrators, and ICT Security Specialists	16.1	14.5	15.5	15.3
263 ICT Network and Support Professionals	26.5	25.2	19.7	23.2
	100.0	100.0	100.0	100.0

[1] The 'total' number of advertised job vacancies relates to the total number appearing in the OFO recoded database, rather the total number of advertisements placed every year in the Sunday Times.

Table 19 shows the number of advertised vacancies and percentage change for each minor group of ICT Professionals across the three year period. In year three, the vacancies recorded was 98.7 per cent more than the number of vacancies recorded in year one.

The business and systems analysts and programmers group recorded the largest per centage increase over the three years followed by the Database and Systems Administrators, and ICT Security Specialists. There is a strong indication that this upward trend may continue (i.e. an r-squared value near/above the 95 per cent confidence level).

The number of advertised vacancies for Network and Support Professionals increased with 72.5 per cent from Year 1 to Year 2, but slowed very quickly in Year 3. this suggests that demand for this group had tapered off (r^2 value of <0.5). Nevertheless, 47.8 per cent more vacancies were advertised for Network and support Professionals in Year 3 than in Year 1.

This kind of analysis is potentially valuable because it gives some indication of the occupational groups in which there appears to be more pressure from employers to hire workers.

The fluctuations in demand from year to year –as recorded by vacancies – are as important to take note of as the proportionate shifts recorded in demand for different occupational groups. This suggests that the ICT work environment is relatively volatile and that trends can quite quickly shift direction.

Table 19: Total job vacancies for ICT Professionals (OFO Occupational Group), by year and minor group					
	% change			Trend line	
	Year 1-Year 2	Year 2-Year 3	Year 1-Year 3 2004 - 2006	shape	r²-value
26 ICT Professionals	81.0	9.8	98.7	↗↗	0.8792
261 Business and Systems Analysts and Programmers	90.0	18.1	124.4	↗↗	0.9378
262 Database and Systems Administrators, and Security Specialists	63.1	16.8	90.5	↗↗	0.9506
263 ICT Network and Support Professionals	72.5	-14.3	47.8	↗→	0.4212

Based on the vacancy data, a survey of the employers that posted vacancies was conducted between July and September 2007. The number of interviews conducted with employers of ICT professionals was proportionate to the number of ICT professional vacancies advertised.

A total of 33 employers were interviewed in connection with 121 vacancies across the sub-occupational groups (Table 20). Of these vacancies, 100 (82.6 per cent) were reportedly filled.

It is important to observe here that the fill-rate obtained in this sample is quite high, averaging 82 per cent for all ICT professions – though obviously this figure would need to be 100 per cent to rule out evidence of a skills shortage. At the same time we must recognize that even in an occupational labour market with a surplus of skills the fill rate on a first round of interviews is not always 100 per cent.

Further insight into the state of the labour market for ICT professionals is provided from the data on applicants. Clearly, the quality of the short-listed applicants is affected by the general suitability of all applicants. In this respect, relatively low proportions of the total numbers of applicants were considered suitable by the employers. This can be an indication of the general low suitability of candidates in the labour market and at the same time it can simply be a measure of the levels of desperation of those unemployed who will apply even for posts outside of there are of expertise.

Table 20: Survey results for ICT Professionals vacancies by OFO Occupational group						
	Vacancies			Applicants		
	Vacan-cies	Filled	Fill Rate %	Appli-cants	Suitable applicants	% suitable
26 ICT Professionals	121	100	82.6	2220	263	11.9
261 Business and Systems Analysts and Programmers	105	85	81.0	1371	195	14.2
262 Database and Systems Administrators, and ICT Security Specialists	8	7	87.5	689	32	4.6
263 ICT Network and Support Professionals	8	8	100	160	36	45.8

Although we have some idea of the success rate of filling posts, there are other relevant questions for future consideration. Which jobs were subject to higher turnover of incumbents, or how career pathing and promotions influenced the appearance of vacancies, since this would have required a time consuming and expensive follow-up with all employers. Some employers are reluctant to divulge too much information about hiring and recruitment as this is considered to be strategic information.

Remuneration

Dramatic growth in employment in a particular occupation over time is likely to reflect a significant rise in demand for that type of worker. Likewise, rapidly rising relative remuneration in a particular occupation may imply that the demand for workers exceeds the supply (Veneri 1999). When demand exceeds supply in a particular occupation, compensation tends to rise relative to compensation in other occupations that require similar education, effort, and conditions (United States National Research Council 2002).

Remuneration is one important incentive to attract and retain workers, in a competitive labour market for specific skills. Remuneration trends can give an indication of changing demand for specific skills relative to supply. Growth in the remuneration of CPAPs compared to growth in the remuneration of all professionals and associate professionals in the economy can be an indication of demand exceeding supply for ICT skills.

Remuneration data can fluctuate widely from one year to another which makes it difficult to determine a trend over a period of time. Therefore an average remuneration of professionals and associate professionals was calculated using two year intervals.

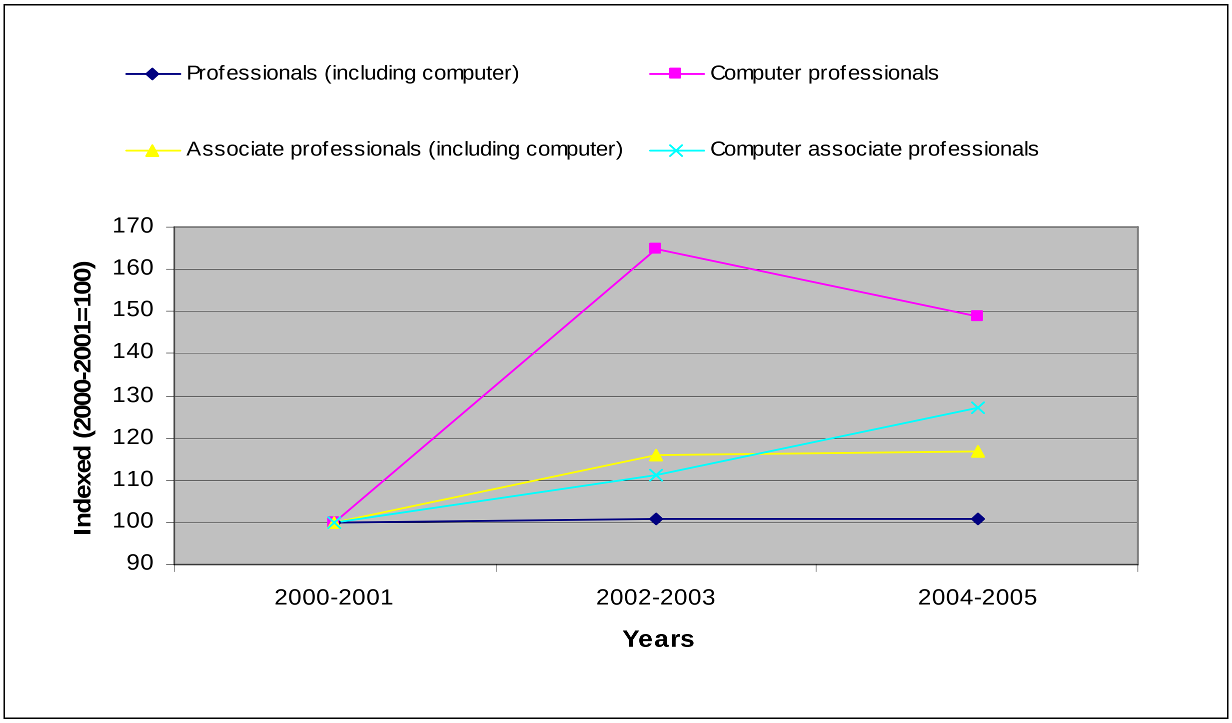
There has been a growth in the remuneration of all professionals and associate professionals over the period 2000 to 2005, as shown in Figure 18. However, the remuneration of CPAPs increased faster than the remuneration of all professionals and all associate professionals.

The remuneration of all professionals grew at 0.9 per cent per annum; while the remuneration of *computer* professionals grew at a rate of 7.4 per cent per annum over the period 2000 to 2005.

The remuneration of all associate professionals grew at 2.9 per cent, while the remuneration of *computer* associate professionals grew 10.8 per cent per annum over the same period.

This is a strong indication of increasing scarcity/demand for CPAPs relative to demand for other professionals. Usually there is more a demand for ICT skills when the economy is growing, as speed in information flow and systems go hand in hand with success in financial transactions and trade.

Figure 18: A comparison of changes in remuneration between all professionals and all associate professionals and CPAPs 2000 to 2005



Source: Quantec, 2007 (StatsSA OHS data for 1996 – 1999; StatsSA LFS data for 2000 – 2005)

Projection of future demand for computer professionals and associate professionals

A number of assumptions were made in order to calculate the demand for CPAPs over the period 2005 to 2015 (Table 21 and 22). These assumptions which refer to key factors that impact on the size of the CPAP workforce are:

1. the average annual growth of 0.4 per cent in the number of CPAPs over the period 1996 to 2005 will continue over the period 2006 to 2015;
2. the ratio of ICT managers to CPAPs calculated for 1996-2005 will be maintained in the years to follow;
3. the ratio of CPAPs and ICT managers aged 60 years and older to the rest of the ICT workforce calculated for 1996-2005 will be maintained in the years to follow. In reality the ratio of workers aged 60 years and older will fluctuate, over time in relation to the overall computer population. Also, the racial composition of this group will contribute to the shape of demand for skills on the basis of equity;
4. CPAPs and ICT managers who turn 60 years old will retire. In reality, numbers of these workers may continue to work after official retirement as contractors. This may slightly lessen demand for certain skills;

5. the average annual growth of 14.9 per cent in the number of deaths among science, engineering and technology (SET) human resources over the period 1997 to 2002 will continue over the period 2006 to 2015;
6. the same ratio between ICT-trained persons emigrating and numbers of ICT-trained who were employed in 2001 in South Africa has remained constant. In reality this may not be the case. There is increasing global competition for skilled workers. The rate at which skilled South African ICT workers emigrate may well have increased.

Based on the above assumptions, we have built two scenarios which provide a slightly different perspective on the demand – supply equation. In Scenario 1, we compute the demand for CPAPs and include another source of demand which is ICT managers. A strong theme in the debate about shortages of ICT workers in South Africa refers to shortages of managers (eg: IT project managers). The critical issue to recognize is that these ICT managers are largely drawn from the ranks of CPAPs. In other words, there is a loss of CPAPS once they are appointed or promoted into management positions. In effect this represents a further source of demand on the CPAP workforce. We have therefore included this factor in our Scenario 1.

Scenario 1: Demand for CPAPs *and* ICT managers: Data was obtained from different sources in order to populate Table 21 based on the factors identified above:

i. The number of CPAPs employed was obtained from LFS data for the 2005 base year. In 2005 there were 49 688 CPAPs;
ii. CPAPs had an average annual growth of 0.4 percent over the period 1996 to 2005. This was applied as a percentage in the following years;
iii. The number of ICT managers from LFS data was calculated by selecting those that had studied an ICT related field of study and were employed as managers (in manufacturing or business services or computing services, or communication). In 2005 there were 12 700 ICT managers. The ratio of 25.6 per cent ICT managers to CPAPs was applied over the following years;
iv. According to the 2005 LFS, 8.6 per cent of employed CPAPs were aged 60 years and older. It is assumed that this 8.6 per cent will retire every year;
v. A mortality figure was calculated by using mortality figures for SET workers, from Kahn et al. (2004). The average annual growth of 14.9 per cent in the mortality of SET human resources over the period 1997 to 2002 was calculated and applied over the period 2006 to 2015;
vi. A United Nations Development Programme case study on South Africa in 2001 (UNDP 2001b) indicated that around 3 000 ICT-skilled workers leave the country each year and this was around 3.35 per cent of the ICT-skilled workforce employed in 2001. We applied this ratio to the number of ICT workers employed each year to generate a projected emigration number.

We simply calculate the following:

CPAPs+ ICT managers – retirement – mortality – emigration = annual demand[5]

Table 21 reflects the outcome of the above calculation for each year. The total requirement of new CPAPs and managers by 2015 to cover losses due to retirement, mortality, emigration, and new demand, is estimated to be 93 452.

Table 21: Projection of demand for computer professionals, computer associate professionals and ICT managers, 2005-2015

Year	CPACs	ICT managers	CPAPs plus managers	New Demand	Aged 60 and older (8.6% of ICT workforce)	Mortality (14.9% average annual growth)	Demand arising from emigration	Total
	n		n	n	n	n	n	n
Base year 2005	49688	12700	62388	n/a	n/a	n/a	n/a	n/a
2006	49877	12748	62625	237	5386	737	2098	8458
2007	50068	12797	62865	240	5406	847	2106	8599
2008	50259	12846	63105	240	5427	973	2114	8754
2009	50451	12895	63346	241	5448	1118	2122	8929
2010	50644	12944	63588	242	5469	1285	2130	9126
2011	50837	12994	63831	242	5489	1476	2138	9346
2012	51031	13043	64074	244	5510	1696	2146	9596
2013	51226	13093	64319	245	5531	1949	2155	9880
2014	51422	13143	64565	246	5553	2239	2163	10201
2015	51618	13193	64811	246	5574	2573	2171	10564
Total				**2423**	**54793**	**14892**	**21344**	**93452**

Source: Quantec, 2007 (StatsSA OHS data for 1996 – 1999; StatsSA LFS data for 2000 – 2005)

Kahn, 2004 (data on mortality); UNDP, 2001b (data on emigration)

Scenario 2: We estimate demand for CPAPs without reference to ICT managers as a source of demand from the CPAP workforce.

Consequently, we use the same assumptions as described in detail for Scenario 1 with one exception. We do not include factor (iii) in our calculations. Our formula is simply:

CPAPs – retirement – mortality – emigration = annual demand[6]

Table 22 reflects the outcome of the following calculation for a particular year. The total requirement of new CPAPs by 2015 to cover losses due to retirement, mortality, emigration, and new demand, is 74 103.

[5] CPAPs (0.4 per cent average annual growth) + ICT managers (25.6 per cent of CPAPs) – retirement (8.6 per cent of ICT workforce) – mortality (14.9 per cent average annual growth) - emigration (3.35 per cent of ICT workers) = annual demand.

[6] CPAPs (0.4 per cent average annual growth) – retirement (8.6 per cent of CPAPs) – mortality (14.9 per cent average annual growth) – emigration (3.35 per cent of CPAPs) = annual demand

Table 22: Projection of demand for CPAPs, 2005-2015

Year	CPAPs	New demand	Aged 60 and older	Mortality	Demand arising from emigration	Total
	n	n	n		n	n
Base year 2005	49688	n/a	n/a	n/a	n/a	n/a
2006	49877	190	4289	571	1671	6721
2007	50068	190	4306	656	1677	6829
2008	50259	191	4322	754	1684	6951
2009	50451	192	4339	866	1690	7087
2010	50644	193	4355	995	1697	7240
2011	50837	193	4372	1143	1703	7411
2012	51031	194	4389	1314	1710	7607
2013	51226	195	4405	1509	1716	7825
2014	51422	196	4422	1734	1723	8075
2015	51618	196	4439	1993	1729	8357
Total		**1930**	**43638**	**11535**	**17000**	**74103**

Source: Quantec, 2007 (StatsSA OHS data for 1996 – 1999; StatsSA LFS data for 2000 – 2005)

Kahn, 2004 (data on mortality); UNDP, 2001b (data on emigration)

Having built and applied a model to project demand, we now move on to develop a simple projection for supply of ICT skills from higher education institutions.

Projecting graduate output between 2005 and 2015

By using the graduate production data from the higher education system (universities and universities of technology) as discussed above in this report it is possible to calculate a projected output figure for ICT graduates by 2015.

The first step in this simple procedure was to calculate the historical growth of graduate output from higher education in the earlier period 1996 to 2005. The growth in output of computer science and data processing graduates at higher education (HE) institutions over the period 1996 to 2005 was 11.9 per cent. This percentage was then used as a multiplier against the actual output of computer science and data processing graduates in 2005 (4 598). According to this method, the total number of CPAPs from HE institutions, entering the labour market between 2006 and 2015, may be 89 729.

We have included two factors that reveal how in effect, the number of graduates from a particular field do not necessarily practice professionally in that field. For this reason we cannot presume a simple linear relationship between graduates and entrants into a particular professional field.

First, our study on demand has shown that 26.4 per cent of those who obtained a high skill qualification in an ICT related field of study, did not work in an ICT field (Figure 6). This is an important issue to bear in mind in supply side calculations. Not all persons who qualify in a field can be counted on to practice in that field once employed. Therefore, we deducted this percentage against the output for each year.

Second, our study on demand revealed that 18.6 per cent of those who studied in an ICT related field of study, worked as managers (Figure 6). We calculate that 90.1 per cent of all managers who studied in an ICT related field of study, worked as ICT managers. On average 20 927 managers have studied in an ICT related field of study over the 2000-2005 period and 18 845 (90.1 per cent of managers) worked as ICT mangers over the same period. Only 1.8 per cent (20 927 managers minus 18 845 ICT managers = 2082 managers) of all managers with an ICT related field of study who were employed (112 690) worked as non ICT managers over this period. Therefore we extract 1.8 per cent (managers qualified with ICT related qualifications, but work in other than ICT management) from ICT graduates, each year, as they will not work in ICT management, but other management.

Based on the factors discussed, the total number of CPAPs from HE institutions, entering the labour market between 2006 and 2015, is estimated to be 64 425 (Table 23).

Table 23: Projected graduate output between 2005 and 2015

Year	HE output: Computer Science and Data Processing	Average annual growth (1996 - 2005) %	Graduates who will not work in an ICT field (26.4%)	Graduates who will work as other managers (1.8 %)	Total: Other work	Graduates that will work in an ICT field
Baseline 2005	4598	11.9	1214	83	1297	
2006	5144	11.9	1358	93	1451	
2007	5755	11.9	1519	104	1623	
2008	6438	11.9	1700	116	1816	
2009	7203	11.9	1902	130	2031	
2010	8058	11.9	2127	145	2272	
2011	9015	11.9	2380	162	2542	
2012	10086	11.9	2663	182	2844	
2013	11284	11.9	2979	203	3182	
2014	12623	11.9	3332	227	3560	
2015	14123	11.9	3728	254	3983	
Total: 2006 to 2015	**89729**		**23688**	**1615**	**25304**	**64425**

Source: Authors' calculations based on HEMIS data over the period

1996 – 2005 (DoE, 1997-2006)

This calculation of supply has, some limitations. Firstly, graduates in other fields of study also form part of the supply of ICT workers. Secondly, internationalization is an increasing trend in higher education and in 2000 and 2004, international students represented eight per cent and seven per cent respectively of the total enrolment at South African higher education institutions (Sehoole 2006). It is not known what percentage of foreign students enroll for ICT related fields of study and return to their home country to practice. Counting this group in the total graduates inflates the real number likely to practice in South Africa. Thirdly, a small percentage of people who obtain qualifications from private ICT training institutions is excluded. One per cent of the output from private ICT training institutions is at an equivalent skills levels to the CPAP skills levels of graduates from higher education (Roodt 2003). These factors could not be taken into account in our model.

Supply and demand

We proceed to comparison between the demand and supply according to the calculations made in our model.

In Table 24 the higher education computer science and data processing graduate supply is compared to the demand for CPAPs and ICT managers arising from new demand over the period 2005 to 2015.

If *ICT managers* are included (Scenario 1), a shortage of 29 027 CPAPs is predicted by the model.

If ICT managers are *excluded (Scenario 2)*, a shortage of 9 679 CPAPs is predicted by the model over the decade.

Table 24: Comparison between the total number of positions that need to be filled to address demand for ICT workers and the output of new graduates, 2005-2015

	Scenario 1	**Year**	**N**
A	ICT workers including managers[1]	2005	62388
B	ICT workers including managers[2]	2015	64811
C (B-A)	Growth in demand for ICT workers		2423
D	Demand arising from death and retirement[3]		69685
E	Demand arising from emigration[4]		21344
F (C+D+E)	Total number of positions that need filling		93452
	Total number of new graduates[5]		64425
	Shortage		**29027**
	Scenario 2	**Year**	**N**
A	ICT workers (excluding managers)[6]	2005	49688
B	ICT workers (excluding managers)[7]	2015	51618
C (B-A)	Growth in demand for ICT workers		1930
D	Demand arising from death and retirement[8]		55174
E	Demand arising from emigration[9]		16999
F (C+D+E)	Total number of positions that need filling		74103
	Total number of new graduates[10]		64425
	Shortage		**9679**

Source: [1]drawn from Table 21, [2]drawn from Table 21, [3]drawn from Table 21, [4]drawn from Table 21, [5]drawn from Table 23; and [6]drawn from Table 22, [7]drawn from Table 22, [8]from Table 22, [9]from Table 22, [10]from Table 23

The most important element to bear in mind is that the labour market environment is highly complex and there is no simple and direct interaction between supply and demand. It is also important to bear in mind that each method used to obtain a sense of how the labour market is behaving must be understood as limited and should be considered in the light of other data and interpretations.

SUMMARY

CPAPs constituted over 40 per cent of the ICT workforce within our broad definition of ICT workers. The next largest occupational group was electronic and telecommunication engineering technicians at 26.6 per cent whereas the related electronic and telecommunication engineers group constituted only 1.9 per cent of the ICT workforce. Media-related occupations constituted only 29.3 per cent of all ICT workers.

The drivers of demand for ‘computer professionals’ and for ‘electronics and telecommunications engineers’ still differs, notwithstanding levels of convergence. For these reasons the detailed analysis focused exclusively on two occupational categories, namely computer professionals and associate professionals.

In the course of analysis in part one we have been able to make limited inferences about possible shortages of computer professionals. In the second part of the analysis, we presented an analytic overview of graduate production from higher education in the fields of study which are considered to be the main source of qualified computer professionals outside of the private ICT training industry.

In the *data from a survey of vacancies* in part three we drew some tentative hypotheses about labour shortages in the computer professional occupational fields. Furthermore in a standard economic theory to an analysis of *data on the remuneration* of professionals and of computer professionals in South Africa, we observed that changes in remuneration of computer professionals is evidence of a labour shortage in these occupations.

Finally, we attempted to bring together in part three the data that we have assembled and analysed in the first two parts of this paper. In doing this, we attempted to *bring the demand and supply sides together so to speak to a projection model* that projects possible demand into the future and predicted a graduate output curve into the future. The curves of demand and supply were then juxtaposed so that a putative shortage/oversupply figure was produced.

Sub-sectors

In looking at the various sub-sectors in which CPAPs worked, it was found that more than seven in every ten Computer professionals were absorbed into the financial and business services sector. The only other sector which attracted more than ten per cent of the population of CPAPs was manufacturing. In 1996-1999, 10.3 per cent of computer professionals worked in manufacturing and this increased slightly to 11.8 per cent in 2004-2005. In contrast there was a sharp decrease in the proportion of computer associate professionals employed in the sector. The factors contributing to this shift would need to be investigated further.

In the financial and business services sector and in the manufacturing sector, changes occurred in the proportions between employment of high level and intermediate level computer professionals. These changes worked in opposite directions. In the financial and business services sector, the number of intermediate skilled Computer associate professionals increased to the point where there was virtually a 1:1 relationship with the higher skilled Computer professionals. In the manufacturing sector, in 1996-1999 intermediate skilled Computer associate professionals outnumbered Computer professionals by 7:3 but by 2005/2005 the situation was reversed and Computer associate professionals were themselves outnumbered 7:3 by Computer professionals.

It is important to seek explanations for these shifts in the skills make-up of sectors which employ large numbers of CPAPs. Did the ICT skills requirements in these sectors change, because new technologies adopted across the industry altered the optimal ratio of ICT high to ICT intermediate skills in enterprises or because enterprises across the industry adopted new business models which reduced/increased the need for intermediate ICT skills or because changes in the labour market after 2000 affected the balance of professionals to associate professionals or because enterprises created career path opportunities through which workers were promoted to full professional status, perhaps with access to additional training? Such questions must be posed and adequate explanations need to be found. These are the kinds of questions that will help us to understand the drivers of ICT skills shortages or over-supply and to respond accordingly. Similar questions are relevant also to sectors which employ smaller numbers of computer professionals, such as the ‘Trade’ and the ‘Transport storage and communications’ and ‘Social and personal services’ sectors.

Over the 2004-2005 period, within the financial and business services sector the overwhelming majority of CPAPs worked in software consultancy and supply, while 13.6 per cent worked in the hardware consultancy, 7.2 per cent worked in monetary intermediation (plus 2.5 per cent in ‘other financial intermediation’), and 4.4 per cent worked in legal, accounting, bookkeeping and auditing environments. There is a relatively sizeable share of employees in ‘other computer related activities’ but further investigation would be required to establish what constitutes this group.

Turning to the manufacturing industry, the bulk of CPAPs working in manufacturing were employed in motor vehicle manufacture with a further 16.9 per cent working in the manufacturing of office, accounting and computer machinery industry. Relatively small numbers were employed in the manufacture of basic iron and steel and of electronic components. The latter statistic gives some indication of how small the electronic component manufacturing sector is in South Africa, while the much larger percentage working in the manufacturing of office accounting and computer machinery sub-sector are engaged largely in assembly of computers rather than manufacturing.

Provincial distribution

The spacial distribution of CPAPs provided a sense of the broad labour market situation within which ICT skills shortages and oversupplies are contextualized. Nine in every ten computer professionals is located either in Gauteng, the Western Cape or KwaZulu-Natal. In each of the other six provinces the share of computer professionals is below two per cent. Difficulties in filling computer worker vacancies will be experienced in the provinces which have smaller GDPs and an even smaller computer professional workforce. The spatial concentration of ICT professionals will be mainly in urban settlements which will further distort access to ICT professionals in provinces where the population is largely rural. Provinces covering large areas make access to computer professional services difficult, because of travel and time costs. These environments will constrain the capacity of government to upgrade, let alone innovate in its use of ICT.

Public and private sector distribution

ICTs is an important channel of service delivery for the future. South African provincial and national government departments and institutions, and municipalities at local government spheres constitute the single biggest corporate market for computer hardware, software and services in the country. However, there has been a gradual decrease in the number of CPAPs in the public sector over the period 2000 to 2005. Private sector employment of CPAPs also declined in the period though not as sharply.

In 2005 as many as 93.1 per cent of CPAPs worked in the private sector and only 6.9 per cent in the public sector. The public sector appears to have shed as many as ten thousand computer professionals in the five year period. However, this shift does not necessarily reflect a direct loss of ten thousand computer professionals from the workforce employed to operate government ICT systems. It is more likely to reflect increased resort on the part of government to outsourcing its IT functions to private companies which design implement and maintain government IT systems. More workers will be employed by private sector enterprises, though they are actually working on government projects. This can lead to a significant underestimate of ICT employment that is dependent on government projects.

There are several important issues embedded in government outsourcing ICT work. Attractive private sector wages draw former public sector IT workers in to the private sector labour market. This is a serious concern for sustaining the integrity of government information and decision support systems in general. It is also problematic since certain government information functions cannot be outsourced for reasons of security and sensitivity.

We must also question whether private sector enterprises which are benefiting from outsourced public contracts are paying sufficient attention to training appropriately skilled people to fulfill their contracts. Claims by private sector companies who are contracted to government about skills shortages may reflect a combination of an alreading existing poor government skills base and a continuing low propensity for private companies to train.

State owned enterprises employ the largest number of ICT professionals followed by provincial, central and local government. Provinces employed only 23.6 per cent of government Computer workers, yet there are nearly 100 provincial level departments with massive service delivery responsibilities including education, health and social welfare in this sphere. This suggests that ICT outsourcing is mainly resorted to at the provincial and national spheres.

Skill levels

The general pattern of recruiting associate computer professionals with intermediate skills and recruiting computer professionals with high skills was retained between the 1996 to 1999 and 2000 to 2005 periods. The fact that a marked increase in proportions of professionals with high skills took place over the 2000 to 2005 period suggests that the education and training supply side institutions did contribute substantially to raising skills among professionals.

But this does not necessarily mean that complaints about an ICT skills shortage were unfounded. The relatively large proportion of intermediate skilled workers in the computer professional category and the high proportion of low skill workers in the computer associate professionals category indicate that a shortage was in evidence in the second period.

Computing professionals category turned out to be the best stocked in terms of appropriate skill levels. Because the skills range of computer associate professionals ranges quite widely, we are less confident in pointing to specific shortages.

Employment according to race and gender

A key question in the post-Apartheid labour market is the extent to which employment equity has taken root. In the case of computer professionals, there was an overall increase of 7.9 per cent in employment over the 1996-1999 and the 2000-2005 periods. Among computer associate professionals there was a more substantial 16.3 per cent increase in employment over the same period. There was a 1.8 per cent increase in the proportions of black computer professionals and a 2.2 per cent decrease in the percentage of white computer professionals between the two periods. Even though there was an increase in the real numbers of all racial groups among the associate professionals, the real and proportional gains were made among white associate professionals, representing a regressive shift in terms of equity needs.

The gender composition of the computer professional occupational categories has worsened between 1996-1999 and 2000-2005. There was an increase in the numbers of females working as computer professionals, but a decline in the employment of females in the associate professional category. Conversely, there was growth in both the male computer professional category and the associate professional category over the same period. Clearly, conditions privileged male employment.

Employment according to age

The distribution of computer professionals according to age is an important parameter to bring into the reckoning from a labour market supply and demand perspective. The population distribution of computer associate professionals appears far healthier than that of the computer professionals. The proportion of computer professionals employed which is younger than 30 is much smaller than for computer associate professionals.

Furthermore, transformation has occurred to a greater extent among computer associate professionals than among computer professionals, as there were quite a number of black computer associate professionals in both the lower as well as higher age cohorts and this trend will continue in future, as almost two thirds of black computer associate professionals are younger than 35 years of age, while 42.3 per cent of the white computer associate professionals are older than 35 an will retire in the near future.

Supply

Given the demand challenges, we move to the current supply of CPAPs which are required to address demand challenges. The main contributor to ICT skilling in terms of volume and variety of learning opportunities is the private sector. As a very small proportion of learning opportunities at private ICT training institutions could be said to be equivalent to a higher education qualification, our analysis addressed only the contribution of South African higher education institutions to the supply of ICT professionals.

Enrolment

Black candidates dominate enrolment at diploma/certificate level and to a slightly lesser extent at the degree level, while white candidates constitute the majority of enrolment at the post-graduate level which is dominated by white males. The share of black enrolments decreases as the level of qualification rises. Decreasing black student enrolment at higher levels of qualification, can be attributed to the attraction to enter the labour market immediately upon completion of the initial qualification or to difficulties in completing the study programme, because of lack of funding, disadvantaged school background or insufficient academic support.

We need to investigate further the position of very substantial numbers of diploma and certificate students, who are mostly black. By establishing the academic background of students, whether they are enrolled on a part-time or a full time basis, what the curriculum of such programmes is, what the vocational-theory balance of such diploma/certificate programmes are, will assist us in assessing the contribution of such qualifications to broadening the ICT skills base and to equity of access to the workplace.

Graduations

With regards to graduations, graduate output yielded an annual average increase of 11.7 per cent. The main locus of growth was with African graduates whose numbers significantly exceeded white graduates for the first time in 2003. The share of white graduates peaked in 2002 and declined over the ensuing years. In effect, African graduate production increased sevenfold over the decade.

Changes occurred in the overall distribution of graduates between qualification levels. Graduates holding certificates and diplomas as a proportion of all graduates declined from 51 per cent to 34.5 per cent, while the share of graduates with degrees increased from 30.8 per cent to 46.6 per cent between 1996 and 2005. Postgraduates as a share of all graduates held the same proportion. This means that there was an increase in the overall qualification levels per cohort over the period that was available to the labour market.

Very encouraging is that by 2005 the number of black, female graduates with computer science and data processing across all qualification levels, was greater than the number of white male graduates. However, it is noticeable that the proportion of male holders of certificate/diplomas declined significantly in relation to all other qualifications between 1996 and 2005, whereas this was not as evident for females. This proportion must be monitored lest increases in the number of female graduates become concentrated among lower qualification levels.

A snapshot of graduate numbers per sub-field in 2005 reveals that only a few are responsible for a major share of graduate production. The major four contributors are: information and database systems, applications in computer science and data processing, computer operations and operations control and programming languages. Together these study fields contribute 75 per cent of all graduates in the computer science and data processing fields. Yet only two, ‘Information and database systems’ and ‘computer operations and operations control’ increased their share of graduates between 1999 and 2005. The question is why these patterns emerged and to what extent the shifts in graduate numbers between the sub-fields resolve or aggravate labour market demand?

It is interesting that three of the smaller sub fields showed strongest growth: computer hardware systems, programming systems and computer operations and operations control reflected average annual growth in graduate output of 20.0 per cent, 17.1 per cent, and 13.7 per cent respectively. Notwithstanding its already large share, annual average growth of information and data base systems graduates increased 11.9 per cent.

The number of graduates in programming languages, other computer science and data processing, software methodology, computer hardware, theory of computation, and numerical computations showed negative growth over the seven years. Further research into the factors driving these processes is worth undertaking.

The dynamics of labour demand and labour supply in the field of ICT, are quite complex. On the one hand, the fields of knowledge and the kinds of qualifications involving ICT that are offered in higher education are overlapping and quite diverse. There is not a direct relationship, for example, between the production of graduates from computer science, and the existence of a particular set of job opportunities only for people with a computer science qualification. An additional factor that contributes to an imprecise relationship between qualifications and job vacancies is substitution. The phenomenon of transferability or mobility of workers between occupations cannot be ruled out in the broad field of ICT.

Thus, to properly understand the broad context of demand and supply among ICT related occupations, it is necessary to refer to a range of qualifications from study fields that are cognate to computer science that may contribute to supply. Therefore, we have identified several cognate fields of higher education study which will contribute to the overall production of high skills ICT workers. We suggest that changes in the graduate outputs from these study fields could impact on the overall situation regarding demand and supply of high level ICT skilled workers.

Other fields of study than computer science and data processing fields of study, such as Business Data Systems and Computer Engineering and Technology, may contribute considerably though unevenly to the output of ICT field related graduates into the labour market. However at this stage, we cannot know how this graduate production impacts on employment and skills shortages.

Supply and demand for graduates

To determine whether there is a real ICT skills shortage or not, was not straight forward for a number of reasons. First, there is no clear demarcation of ICT work. Most professionals have an overarching professional council that defines the particular profession, level of qualifications required, registration, work reservation and codes of conduct. CPAPs have no overarching council and ICT work is changing continuously, new ICT occupations develop or some become extinct with rapidly new emerging and converging technologies.

Secondly, available ICT supply and demand data are not very specific, as the occupational codes used by Statistics South Africa are very broad and include a variety of occupations and functions under one code.

Third, data on migration is not readily available in order to calculate immigration and emigration figures for ICT workers. If available, migration figures are at its best only given for Science, Engineering and Technology workers combined.

Fourth, ICT study fields at education and training institutions do not match ICT occupations on a one to one basis. Some other fields of study are also output in the ICT work environment. About half of graduates with a qualification from a higher education institution in an ICT related field of study occupied positions as CPAPs, while nearly one-in-five were managers in any sector. One in four graduates were employed in work other than an ICT profession or associate profession (Figure 6).

Fifth, all graduates at South African education and training institutions are not necessarily South Africans and foreign graduates return to their home countries after obtaining a qualification at a South African institution. Output data could thus be a bloated version of the actual supply from education and training institutions.

Sixth, the pathways in becoming an ICT worker are varied and on the job training, a certificate or diploma obtained at a private or FET college, or a diploma or a degree obtained at a higher education institution, be it a university of technology or an university, can all be stepping stones towards becoming an ICT worker.

Seventh, the rapidly changing technology environment has as a result outdated knowledge and it becomes a challenge to match training and supply with demand in the labour market.

CONCLUSION

The rise in remuneration of CPAPs relative to compensation for other professionals and associate professionals indeed is an indication that demand exceeds supply. Remuneration, however, can also increase as a result of productivity and the remuneration of other professionals and associate professionals can be low as a result of poor salaries in some categories such as nurses and teachers.

According to vacancies as advertised in Career Junction (2008) over three years (2005 to 2007), almost a quarter (24.5 per cent) of vacancies were for ICT workers, 20.1 per cent for financial positions, 8.4 per cent for engineering positions and lower percentages for vacancies in other positions which is an indication of a demand for ICT workers.

According to current employment, 5.1 per cent of *all professionals* are computer professionals. A 4.4 per cent vacancy rate for computer professionals among all professionals, according to our survey of vacancies, could indicate that a shortage in computer professionals is experienced. Vacancies for ICT professionals were predominantly for Business / Systems Analysts and Programmers, ICT network and support professionals and then also for database and systems administrators which includes security specialists according to our survey of vacancies.

Compared to computer associate professionals it seems as if there is more of a shortage for computer associate professionals than for computer professionals, as a 9.7 per cent of vacancies for *all* associate professionals were specific for *computer associate professionals* according to our survey of vacancies. According to current employment, however, only 1.2 per cent of *all* associate professionals are *computer associate professionals*. The demand for computer associate professionals is thus higher than the current employment in proportion to other associate professionals.

According to our survey of vacancies, there does not seem to be such a high demand for ICT managers as for CPAPs. Only 1.2 of all managerial vacancies was for ICT management vacancies, while 14.3 per cent of all managers that are currently employed, are ICT managers. It must, however, be kept in mind that ICT managers are usually head hunted.

The literature sites various skills shortages, but ICT managerial skills and business skills to coordinate various processes and systems seem to be an important overarching shortage that impacts on other ICT skills shortages. It is for instance argued that business skills need to be acquired first, before ICT related qualifications are pursued. According to the survey of employers that posted vacancies, relatively low proportions of the total numbers of applicants were considered suitable for vacant positions.

According to our projection model, a shortage will indeed be experienced in the future if graduate output does not increase. A greater shortage will be experienced as a result of a demand for ICT managers. ICT managerial skills, however, requires not only training and education, but also experience which is hard to come by.

A prominent argument is made to the effect that a gap exists between the skills sought by employers and those found in the workforce, mainly because of rapidly changing skills requirements. However, these conditions may be exacerbated by sectoral growth. In other words, even if skills needs driven by technology change were taken care of, economic growth in ICT-using sectors would in its own right add further pressure for skills such as business and managerial skills.

The role of knowledge workers and information workers will become increasingly in demand as the diffusion of ICTs throughout all sectors will increasingly require ICT skills, as indicated by various sources, including our projection model.

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