

**South African
Computer
Journal
Number 16
April 1996**

**Suid-Afrikaanse
Rekenaar-
tydskrif
Nommer 16
April 1996**

Computer Science
and
Information Systems

Rekenaarwetenskap
en
Inligtingstelsels

**The South African
Computer Journal**

*An official publication of the Computer Society
of South Africa and the South African Institute of
Computer Scientists*

**Die Suid-Afrikaanse
Rekenaartydskrif**

*'n Amptelike publikasie van die Rekenaarvereniging
van Suid-Afrika en die Suid-Afrikaanse Instituut
vir Rekenaarwetenskaplikes*

Editor

Professor Derrick G Kourie
Department of Computer Science
University of Pretoria
Hatfield 0083
Email: dkourie@dos-1an.cs.up.ac.za

Subeditor: Information Systems

Prof Lucas Introna
Department of Informatics
University of Pretoria
Hatfield 0083
Email: lintrona@econ.up.ac.za

Production Editor

Dr Riël Smit
Mosaic Software (Pty) Ltd
P.O.Box 23906
Claremont 7735
Email: gds@mosaic.co.za

World-Wide Web: <http://www.mosaic.co.za/sacj/>

Editorial Board

Professor Judy M Bishop
University of Pretoria, South Africa
jbishop@cs.up.ac.za

Professor R Nigel Horspool
University of Victoria, Canada
nigelh@csr.csc.uvic.ca

Professor Richard J Boland
Case Western Reserve University, USA
boland@spider.cwrw.edu

Professor Fred H Lochovsky
University of Science and Technology, Hong Kong
fred@cs.ust.hk

Professor Ian Cloete
University of Stellenbosch, South Africa
ian@cs.sun.ac.za

Professor Kalle Lyytinen
University of Jyvaskyla, Finland
kalle@cs.jyu.fi

Professor Trevor D Crossman
University of Natal, South Africa
crossman@bis.und.ac.za

Doctor Jonathan Miller
University of Cape Town, South Africa
jmiller@gsb2.uct.ac.za

Professor Donald D Cowan
University of Waterloo, Canada
dcowan@csg.uwaterloo.ca

Professor Mary L Soffa
University of Pittsburgh, USA
soffa@cs.pitt.edu

Professor Jürg Gutknecht
ETH, Zürich, Switzerland
gutknecht@inf.ethz.ch

Professor Basie H von Solms
Rand Afrikaanse Universiteit, South Africa
basie@rkw.rau.ac.za

Subscriptions

	Annual	Single copy
Southern Africa:	R50,00	R25,00
Elsewhere:	\$30,00	\$15,00

An additional \$15 per year is charged for airmail outside Southern Africa

to be sent to:

*Computer Society of South Africa
Box 1714 Halfway House 1685*

Editor's Notes

The last issue of SACJ, a special issue on IT and Development, was sponsored by a generous grant from the Development Bank of Southern Africa. Unfortunately, confirmation of the sponsorship was only received after the edition had been printed and it was therefore not possible to formally acknowledge the grant at that stage. It is a pleasure to emphatically and gratefully do so now. The fact that the special issue has been very well received, both locally and internationally, is a testimony to the fact that it was money well spent.

The next issue of SACJ will also be a sponsored special issue and deal with the theme of Computer Security. It is being compiled at the initiative of Basie von Solms who will be acting as the edition's guest editor.

This present edition, sandwiched between the two special editions, contains the customary fare of local research contributions. It also contains a guest contribution by Edwin Blake that was initially compiled as a joint response by several leading academics to the recent Green Paper on Science and Technology. It was vitally important to give an IT perspective to this document, and the IT community is indebted to those colleagues who took the initiative to do so. This edition of SACJ also contains the results of a survey taken last year by Judy Bishop on academic IT resources. The figures make for interesting reading. They will no doubt be deployed by every IT department to prove how much worse off they are than everyone else, thereby applying maximal pressure on their respective administrations to get more resources.

Readers will notice that the editorial board of SACJ includes several new names and that three former board

members have declined invitations to continue their membership. On behalf of the readers, I would like to thank these former members for their encouragement and services rendered. In the early years, Gerhard Bath provided a delightful survey of neural networks; Steve Schach continually supported the journal with articles and feedback at a time when there was substantial pressure on overseas academics to do otherwise; and Pieter Kritzinger can rightfully claim to be the prime inspirer of many improvements brought about by the journal over the years.

We welcome the new members to a three year term of office and trust that their association with SACJ will be mutually beneficial. SACJ is privileged to have so many distinguished international names offering such visible support to its efforts in building up IT research in this part of the world.

The new blood in the editorial board highlights the need to replace SACJ's aging editor. Having done the job for several years now, it is clear to me that a fresh approach, bringing new enthusiasm and ideas, is precisely what is needed at this stage. In fact, some might say that a change is rather overdue. The matter is in the hands of the SAICSIT executive committee who is currently seeking a suitable candidate. I will continue with the job until such a person is identified, and I will gladly assist in ensuring a smooth transition. The rest of the editorial team – Lucas Introna as IS subeditor, and Riël Smit as production editor – will remain at their posts to continue their sterling work.

Derrick Kourie
Editor

SACJ is produced with kind support from Mosaic Software (Pty) Ltd.

Guest Contribution

The Green Paper on Science and Technology

South Africa's Green Paper on Science and Technology was prepared by the Department of Arts, Culture, Science and Technology. It is a consultative document and forms the first step in preparing legislation on Science and Technology Policy for South Africa. It is to be followed by a white paper and then the submission of legislation to parliament. The Green Paper consists of chapters and sections that explains the context of issues facing the country: the issues themselves are phrased as questions with a choice of possible options being proposed.

The Green Paper introduces the "Crisis in South African Science and Technology" and shows that there has

been a decline in spending on Science, Engineering and Technology (SET) research and development. Research and development is needed to improve the quality of life for all, improve our international competitiveness and develop a well-educated population. The paper proposes a National System of Innovation that embraces the broad range of activities from high technology to the promotion of incremental technical changes in traditional activities — it covers all domains of innovative activity.

The document itself can be consulted on the web at "<http://wn.apc.org/technology/stgreen/>".

Information Technology and South Africa's Green Paper on Science and Technology

Collected comments on South Africa's Green Paper on Science and Technology by researchers on the information technology related programmes of the Foundation for Research Development.

Edwin Blake

*Department of Computer Science, University of Cape Town, Rondebosch 7700.
edwin@cs.uct.ac.za*

Abstract

If an effective national system of innovation is the main proposal of the green paper then information technology (IT) has to play a very central role in that system. Supporting IT effectively will also mean supporting innovation in IT.

Information technology both enables, and crucially depends on, a national system of innovation. Any white paper on Science and Technology should devote special attention to information technology in view of its crucial and exceptional role in technology innovation.

The IT industry in South Africa, particularly niche applications development, can become a major driver of the economy, both to provide local IT solutions to development needs and to provide export products. It can be a major force in supporting employment in small, medium and micro enterprises (SMME's). The information society makes great demands on human resources. Current deployment of IT is hampered by having far too few people with an ability for innovation in IT. Exploiting the numerous potential benefits of IT will be greatly enhanced by having a more technology literate population.

1 Introduction

Information Technology (IT) is both a leading field of research and development and a profound agent for radical change in our economy and society. It seems set to become the key enabler of scientific, technical and social advance in the coming decades. In this role it may even surpass one of its parent disciplines, mathematics.

We believe that the Green Paper does not recognize the

very special and exceptional role that Information Technology plays amongst the research disciplines. The special enabling role of mathematics is recognized, for example, but not that of information technology. (Note: the name information technology is used to indicate a broad range of converging fields encompassing, Computer Science, Informatics, Telematics, etc).

Innovation plays a very central role in computer science. In IT education mere factual knowledge has a partic-

Acknowledgements

The writing of this document was initiated and an outline was discussed at a meeting of information technology researchers convened by the Foundation for Research Development on the 21st February 1996. A working document was produced and substantial contributions (in the form of complete sections) were made by: Prof Peter Clayton (Dept of Computer Science, Rhodes University), Prof Roelf van den Heever (Dept of Computer Science, University of Pretoria), Prof Anthony E Krzesinski (Dept

of Computer Science, University of Stellenbosch), Mr Philip Machanick (Dept of Computer Science, University of the Witwatersrand), and Prof Jan Roos (Dept of Computer Science, University of Pretoria).

The document was subsequently circulated to all team leaders of FRD funded information technology research programmes. Comments received have been incorporated into the text. Responsibility for final editing (and the remaining errors) lie with Edwin Blake.

Edwin Blake

ularly and obviously limited life span, the educational goal (once one goes beyond providing basic IT awareness) must be one that fosters independent lifelong learning. Computer programming is a creative activity more open to radical innovation than other engineering disciplines.

While South Africa was ranked very low in a recent World Competitiveness Report its use of the internet, by contrast, is ranked very highly. Although causes have not been investigated one can note that the use of the internet was pioneered by local universities and first established commercially by small local entrepreneurial companies spun off from our universities. This model of using centres of expertise to nurture SMME's in IT has proven very valuable worldwide: it is one of the strategies proposed below.

1.1 Outline of the Document

The next section is a critical overview of the approach adopted towards information technology in the green paper. It identifies a major misunderstanding. Section 2.1 deals with mechanisms for IT development and deals in more detail with the issue of intellectual property rights. A major limiting factor on our effective use of IT is inadequate human resources (Section 2.2).

The next major section (3) considers further comments on the green paper in terms of the issues and questions posed. Information infrastructure (Section 3.1) is followed by research and development in the higher education sector (Section 3.2). The vital role of IT in industrial competitiveness leads to a number of recommendations (Section 3.3), these topics are also related to research and development funding (Section 3.4). The special role of IT in education is next discussed (Section 3.5). The impact of IT on society with a number of illustrative examples is presented in Sections 3.6 and 3.7.

A conclusion listing some policy objectives (Section 4) is followed by appendices on sections of the green paper with passing references to IT and an overview of IT support policy in Australia.

2 Approach to Information Technology in the Green Paper

The green paper addresses itself to an effective national system of innovation (NSI) in Science, Engineering and Tech-

nology (SET) — this is the key proposal and the essence of the document. It goes on to motivate the need for innovation:

A coherent and adequately resourced NSI would form the major instrument to ensure that science, research and technology contribute to the national objectives of:

- an improved quality of life for all
- improved international competitiveness for South African economic activity
- a well-educated population capable of participating fully in the new South Africa

Information Technology is mentioned in passing in a number of sections and they are listed in Appendix A. The approach to information technology is mostly rather accepting of a current snapshot of the state of the art: it is taken as a given fact of life. There is little questioning of its role, its future innovations, its future possibilities. Current commercially available advances, the ones that have so transformed science in the eighties and developed societies in the nineties (and certainly the whole world in the dawn of the next millennium) are very properly mentioned: the web, the internet, gigabyte storage on a postage stamp, etc. But this is not seen as a point on an exponential curve of development. It is recognized that IT changes, but dealing with its astonishing rate of change and the profound consequences is little emphasized.

Actually one can say that currently IT is best characterized as unrealized potential. It is *the* key field for innovation! If there is one area a "NSI" cannot ignore it is the innovations needed to make IT useful to our country. Our industrial and commercial competitiveness, our education, health care, "edutainment", public awareness, quality of life, will be crucially determined by our ability to take part in the global information society.

A key area for spending R&D cents must be to make South Africa a beneficiary and not a (marketing) victim of an imported IT industry.

2.1 IT Development

As mentioned above, the green paper does not reflect a deep understanding of the pace of changes in the field of information technology and the consequences of that. It also shows little appreciation of what it will take to have IT develop to fulfil local needs. Section 10.2 of the green paper shows this very well (it is quoted in Section 3.6 below).

That section argues that IT will benefit automatically from government support for the telephone network, radio and television. It is a common mistake to confuse IT with some sort of public utility whose function is to distribute information. Information is not like water or electricity. "Information" as such does not exist. Developing IT content and applications is a complex and creative engineering task. IT is much, much more than the "pipes" for information. IT will never benefit unless there is explicit government support for a development of user orientated information technology.

The section goes on to talk of setting up a long-term government plan to provide equipment countrywide over 10 to 15 years! Could one in 1980 have set in motion any workable plan to provide IT services in 1995? And the rate of change is still accelerating. IT planning must be very different to other types of government planning.

IT planning should revolve around the establishment of centres of excellence and innovation to guide IT developments in desired and continually researched local needs. It should be coupled to national community access centres (see below in Section 3.1) coupled to the proposed Centres of Excellence in IT innovation (Section 3.3).

2.1.1 Intellectual Property Rights

A particularly pressing issue in IT development is that of intellectual property rights (IPR). Section 6.10.1 (of the green paper) deals with "Intellectual property rights". It mentions that "in our haste to conform to GATT and other trade agreements, we [should] evolve a regulatory framework which assists rather than hinders local innovation." This is particularly relevant to IT (along with the life sciences). Developing countries need an intellectual property rights system that encourages innovation and allows fair rewards without stifling competition.

The various IPR systems have an increasingly important economic exchange value beyond being a means of protecting the fruits of innovation. IPR's in the hands of large companies of the three major economic powers (US, Europe, Japan) are becoming a major factor in foreign trade. IPR's allow the conquering of export markets. For such companies extensive holdings of IPR's are a valuable asset. Via cross-licensing agreements these IPR's can allow large companies to proceed with innovation while preventing newcomers, who are not party to such agreements, from entering the field. Thus there is an incentive for such companies and countries to extend the scope and lifetime of IPR systems far beyond what would be required to encourage innovation.

It is possible that IPR's on software are being extended in just such an innovation stifling way. The recognition of patents on algorithms and software (as opposed to using the mechanism of copyright), which is apparently being pressed by the US, may be an attempt to curb the inherent competitive advantage of developing countries in the international software development market. Patents have a relatively long lifetime (20 years is common, and in software this covers 4-5 generations). An algorithm is more

an idea underlying an artefact rather than an artefact itself, and traditionally ideas were not considered patentable. In IT, with its high rate of innovation, patents are also a costly protection scheme unsuitable to small businesses.

While further investigation is needed, it should be clear that the wishes of the developed world may not be in the interests of our country, nor in the interests of IT innovation. Legislation is needed to regulate the situation. Unfortunately no concrete recommendation can yet be made on this complex issue, except to note that it needs to be addressed by a interdisciplinary team of legal and IT experts.

2.2 Human Resources for IT

A major issue not addressed by the green paper is the growing need for increased capacity in information technology innovation, particularly in terms of people, but also in terms of research equipment. IT demands will far outstrip the supply of skilled people.

Human resources are thus the essential factor. Initial training must be complemented by a life-long training system that constantly adapts skills in the face of the ongoing innovation in IT. The pace of IT change will only be acceptable if workers are informed and educated. So another implication of IT innovation is a pressing need for IT skills at all levels. A nationwide system of certification at lower levels is needed to regulate the current plethora of commercial IT "qualifications". At the tertiary level such a national qualifications framework is more problematic given the extremely high rate of innovation in the field — any fixed curriculum is likely to be out of date by the time it is approved.

Industry demands will draw increasing numbers of staff and students away from the higher education sector. The real danger exists that IT education will cease to be effective at our universities. Students will not undertake higher degrees and research staff will leave unless there is a national priority assigned to increasing IT innovation capacity. Without a national IT innovation programme the seeds of South Africa's information society will be consumed before they can bear fruit.

3 Sections and Issues of Special Interest to IT

The green paper generally deals with issues that steer clear of mentioning specific disciplines. However some do refer to IT and some depend crucially on IT. In this next subsections we consider these.

3.1 Information Infrastructure

The first section of special interest to IT is 6.9 (Information Infrastructure for SET Performers). It is currently seen in the context of libraries and the service is seen as complementing and perhaps replacing libraries.

We believe, in line with the universal enabling role of information technology, that this section should really concern itself with universal access by all communities to information technology services. The issue is one of

effectively extending the (telecoms) concept of "Universal Service" in the information age. The "Information Infrastructure" links closely with telecommunications: essentially specifying the bandwidth, quality of service and other requirements of the telecommunications infrastructure. IT itself stretches into all modern processes of society either in a self-contained role or in a network distributed role.

Libraries and library-like services will be a part of that. IT is not an "exciting" technology: it is a *vital* technology. It is a great deal more cost effective than alternatives, *once one stops seeing it as a single application*. A *Community Access Centre* to the Global Information Society is much more than a "capital intensive" library! It is a training centre, an interactive consultation centre with centres of expertise, a multimedia cultural centre, a communications centre, a market price ticker, and so forth.

The issue raised in Section 6.9 is the following:

Issue 6.16:

What are the key elements of a strategy to address the information infrastructure requirements of the SET community and the broader public?

The key element must be a system of public access to a national information technology infrastructure. Such an infrastructure comprises the wires and other links to bring the information to the remotest areas. Much more importantly it comprises relevant and useful content provided by useable applications. The cost of providing such a "Universal Service" would be enormous even if limited access is provided through community centres. What is required, is a well thought through and regularly updated plan for a staged deployment and updating of the Information Infrastructure. The regular revision of any plan in the light of advances in the field of IT is absolutely vital. This plan should be drawn up transparently and also define the role of industry.

Keeping track of changes in IT necessarily implies a system of innovation in that field. Unless such expertise is cultivated one cannot keep abreast of the exponential growth of the field and one is left at the mercy of the global silicon snake oil peddlers.

Single coordinated approach to information provision by government and a government wide IT strategy is supported — it is important to harmonize all Information Infrastructure initiatives. The role of this "single point of co-ordination" will be multi-disciplinary in that role-players from IT and telecommunications will be involved as well as other stakeholders.

A major growth opportunity, that should not be underestimated, is that as many as possible local SA expertise, industry members, etc should be used to design, build and maintain the Information Infrastructure.

There should also be a "single point of co-ordination" for the harmonizing, stimulation, planning, monitoring, etc of general IT development initiatives (applications research and development, data content provision). This group should closely liaise with the "single point of co-ordination" on the Information Infrastructure but it should

be a different group.

Although the "single points of co-ordination" are very important to optimize activities, there is a danger that they can become bottle-necks to new development. Therefore their regulatory roles should be minimized. Innovation is easily stifled by regulation and it should be appreciated that many efforts to regulate IT boil down to attempts to regulate research. Such attempts are recipes for obsolete technology. "Harmonizing SET information infrastructure" is not an easy task.

3.2 Research and Development in the Higher Education Sector

Issue 8.2:

What national objectives should determine the main orientation of the R&D activities of the HES?

There are three major objectives which apply particularly in the case of IT: competitiveness, social upliftment and development and long-term growth.

Competitiveness implies not only keeping up with overseas industry, but identifying areas we can be ahead of them. Higher education can address both, through education in the first case, and advanced research in the latter. However, more contact with industry to feed ideas both ways is needed.

Social upliftment and development addresses the problems of the RDP. R&D can support this goal both by providing graduate students of disadvantaged groups with high-end career opportunities and by doing research to support the RDP's objectives.

Long-term growth requires that there be advanced research both in theory (which although not applicable now, may have application later) and in analyzing and understanding industry trends. Understanding trends is especially important where computer technology is concerned, since the rate of improvement in processing power for a given cost is a factor of two every 12 to 18 months.

The general enabling role of IT implies that there is not such a dichotomy between the two options presented as may be expected.

Option 1

The national SET policy must be guided by economic projections of HRD and R&D needs to create a competitive advantage in specific key areas such as agriculture, information technology, and so on.

The specifics noted in Option 1 apply not only directly to computer and related industries, but it should be noted that all other sectors require broad infrastructure. That infrastructure includes computers, networks (especially but not only the internet), telecommunications, transport, etc. For this reason, Computer Science should be seen as an enabling technology for *all* other sectors, and not only in narrow terms.

Option 2

The aim of the HES must be an overall investment in human capacity of a scientific and technical

nature, not targeted too closely at specific capabilities and markets, realizing that such investment in capacity can by itself be a driving force in the economy.

A broad goal in investing in human capacity also requires that infrastructural technologies be available – especially those which are productivity amplifiers. Computers, telecommunications, etc. again are important. However, if we are purely consumers of these technologies, without advanced research to find uses that suit our unique requirements, we will not be realizing the full potential of our human skills in other areas. Example: computer visualization is an area which can vastly improve productivity in sectors such as geology and medicine. However, much original work needs to be done to suit local problems. Another example: safety in manufacturing processes can be enhanced by computer methods (more accurate control of plant, simulation of potential problems).

3.3 Role of IT in Industrial Competitiveness and Reconstruction

Issue 8.7:

What mechanisms must be introduced to promote better correlation between the R&D activities of the HES and the industrial sector?

A first option is to create a database of IT R&D projects that currently or in future may contribute to RSA international competitiveness. The database should contain indications on which projects are considered so worthwhile that industry would be willing to sponsor them.

Option 1

HES-Industry collaboration programmes, such as the DTI-FRD's THRIP programme, should be further developed and financially strengthened. The R&D statutory funding bodies should take responsibility for bringing industry and the HES into negotiations on collaboration.

General incentives, e.g. THRIP programme, tax incentives, and offset arrangements for foreign firms wishing to sell to government, should be developed to encourage co-operation between industry & HES. The current, restrictive, rule governed approach evident in some of these programmes should be replaced by a *delivery orientated approach* which focuses more on facilitating the desired results.

Option 2

The HES must establish special programmes to facilitate the growth of R&D activities in the SMME sector.

A particularly effective technique for stimulating innovative IT SMME enterprises is to establish *Centres of Excellence and Expertise*. This should target identified niche applications fields in order to exploit and develop competencies of researchers. Developers from HES and industry/SMME sector can be supported in collaborative projects.

IT development is a labour intensive activity of itself. Increasing the effectiveness and competitiveness of indus-

try and commerce will further strengthen sustainable job creation prospects.

Channels should be opened up to international, especially USA, venture capital markets. Active development of international IT export markets will act as a stimulus for local IT industry and HES' R&D. An environment for more significant co-operation with multinational companies will leverage local skills and further development of such skills and abilities.

The recommendation is thus a combination of government funded initiatives and co-operative projects with multinational companies that invest and transfer technology. Currently IT enabled advances for local industry seem usually induced via their international contacts. Established local companies (with certain exceptions) have a sorry record in IT innovation.

At local government and community level an economic (micro level) atmosphere conducive to such activities should be established. Exact details could be learnt from other similar countries that have succeeded in doing this.

Tertiary institutions themselves do not have the resources to bootstrap the process.

Issue 8.8:

What structures, mechanisms and programmes will reinforce the contribution the HES can make to the reconstruction challenges facing South Africa?

Option 1

The National Research and Technology Audit should show up deficiencies in R&D supporting reconstruction. This should form the basis for a revision of research priorities of universities and technikons to include projects in areas affecting quality of life such as water reticulation, sanitation, energy provision, etc.

Option 2

Universities and technikons should be encouraged, via suitable funding incentives, to establish community interface mechanisms aimed at developing effective outreach programmes

Measures which would contribute to the interfaces:

- creating units to provide an interface with communities
- establishing partnership programmes with CBOs and NGOs
- running community-based extramural programmes
- providing central facilities to facilitate community contact, for example, through an Office of External Affairs or Deputy Vice Chancellor of Community Relations.

As remarked above (Issue 8.7) an internationally proven and effective mechanism for stimulating effective SMME's in IT and related industry is the establishment of centres of excellence and expertise in targeted fields.

A useful measure, given the rate of advance of IT, would be the establishment of an IT "wake-up" think-tank whose brief is to identify key areas where IT technology can be applied for the benefit of South Africa. Such a unit should generate proposals and funding mechanisms that will steer the local IT community to adapt to produce these benefits. It should also identify the paradigm shifts needed of the people that can potentially benefit from such projects. Currently advanced IT resources in SA are very thinly spread — a fact that will have to temper these plans (see also Section 2.2).

3.4 HES Research and Development Funding

Issue 8.12:

How can the funding of R&D in the HES be more suitably organised so as to direct R&D activities towards the needs of economic growth and reconstruction?

Option 1

The statutory funding agencies should be rationalised so as to decrease overhead costs and improve co-ordination and coherence. A model could be to reduce the number of agencies to three:

- one for engineering, the physical, biological, agricultural and geological sciences
- one for the medical sciences
- one for the human and social sciences.

Option 2

The universities and technikons must diversify their research portfolios to facilitate increased spending by the private sector in HES R&D. At the present time the private sector contributes only 10% of the R&D funding in the HES. This is very low by international standards.

Option 3

The R&D component of the GUF¹ should be more directed in its distribution and utilisation, and mechanisms should be developed to monitor the utilisation and outcomes.

Option 1 appears to be unworkable: how could one agency with reasonable staffing and expertise handle "engineering, the physical, biological, agricultural and geological sciences"?

Option 2 goes to the heart of the matter: the semi-colonial and often exploitative nature of many international companies that do business in SA. Particularly in IT they appear to be only interested in selling their products. They offer their local staff sufficient training to sell and maintain (where maintain is in fact replace parts) their products. They are not interested in developing products or technologies in SA. Only government, by means of incentives, can oblige them to do so. In this regard, Australia forms a possible model for SA.

In Appendix B some material is attached on how Australia has attracted major multinational high technology companies into collaborative ventures with Australian uni-

versities, and how incentives have been made available to Australian universities to focus their research into product-oriented activities. It also contains a critical evaluation of the Australian experience.

3.5 The Role of IT in Education and its Relation to Mathematics

Issue 9.1

What mechanisms should government introduce to improve the teaching and learning of mathematics, science and technical/technological subjects at the pretertiary level?

Use aggressive teacher re-training programmes in holidays. Distance education can play a role here.

Issue 9.2:

Should mathematics and science be compulsory subjects for all pupils for the duration of their pretertiary education? A motivation should be provided for the answer to this question.

No. School children should not be forced but convinced of the importance of mathematics. There are many ways to do this. Although mathematics is important if you want to follow a SET career it is not that critical for all people. A working knowledge of computers is much more valuable to everybody.

Issue 9.3

Should technology education be part of the compulsory education curriculum? If so, how should it be implemented? Please provide a motivation.

No. School children should not be forced but convinced of the importance of technology. A major component of technology education should be computer literacy. Hands-on lessons will not be possible in all schools but it is extremely important and industry should be encouraged to help. Aggressive teacher training programmes in holidays should be followed to create the teaching staff. A good way of motivating teachers to cooperate is to ensure that adequate facilities are provided and to pay all technology and mathematics teachers and additional allowance. Basic computer literacy can be taught as an interim measure even on obsolete equipment, provided support for such equipment is available.

Issue 9.4:

What mechanisms should be introduced at the local, provincial and national levels to integrate information and communication technologies into the education process to improve the utilisation of the education resources and the quality of learning?

The deployment of IT based distance learning country-wide in schools over the next decade will be limited by the expense. School students should be given access where possible but in the short run the target groups for this technology should be teachers and university students.

It is important to remember that linking education institutions is a very small part of the problem. The major

¹GUF = Government University Fund

part involves particularly the production of lesson material, but also end equipment, application software, trained staff and procedures.

Distance learning can and will certainly play an important role in work-force training (they are more motivated and it will be paid for by industry) and in universities / technikons (it is cheaper to link them together). It is also logical to start by linking tertiary education institutions because more can be gained with less investment.

3.6 IT to Support Democracy and Society

Refer to green paper Section 10.2 (Impact of Technology on Democratisation)

While we believe that IT can help to make information available and to exchange information, it is a potentially powerful force to either enable or prevent democracy (Was IT not used by the apartheid regime to control pass books, keep track of exiles, etc?). Unfortunately IT is not a guarantee for a good government, not even a guarantee to democracy.

Issue 10.3:

How can we enhance the role of information technology in making information, needed to exercise public policy options, readily available?

Information technology will benefit automatically from ensuring the technological capacity exists to maintain and extend the telephone network, radio and television to all parts of the country, and also from enhancing the capacity of the local publishing industry. What else could be done?

Option 1

All major national issues, on which public input is required, be set out with the necessary supporting information and made available on the internet or world-wide web servers. This facility could eventually be extended to regional and local issues. Computers linked to the network could be made available at schools or public libraries for ready public access.

The government and various political parties are already using this method to increase access to information. A long-term plan could be put into place to provide the required equipment country-wide over 10 to 15 years. Innovative solutions should be applied such as workstation access to internet via low cost terminals, using the memory of a central server rather than having their own internal memory. Adopting such a plan would stimulate the local electronic and information industry, with major economic and HRD spin-offs, in addition to its benefits of providing modern information technology countrywide in support of the educational development thrust.

The assumptions on the nature of IT development underlying this section are particularly problematic, it is critically analyzed in Section 2.1 above.

Making policy options accessible can be vastly enhanced if there is easy access to the internet. However the goal of participatory democracy is not met if access is restricted to an elite. Work needs to be done in rural telecommunications, strategies for making internet access publicly available (libraries, community centres, etc.).

Funding such development should be pursued by a combination of public funding to seed projects, and finding ways of selling small value added services (publishing on the internet for example), to make development sustainable.

Widespread access to the internet as proposed is a good idea – but some thought should be given to content provision, not merely providing “terminals”.

Content should be set up in the form of local encyclopaedias, on-line school text books, discussion forums, etc. Publishing on the internet for the school system should be encouraged; there should be a vast body of free information, and the best should be rewarded by payment, to encourage the best authors to do more.

If a “terminal” policy is used, the terminals should be designed to upgrade to a full computer, for those whose usage warrants it. Otherwise we will see the Beltel phenomenon: a technology that dates fast, with no upgrade path.

Care should be taken to avoid building an assumption of highly centralized servers into the system. This should instead be seen as the initial point, from which growth can occur, once skills become more widespread. A true “information” society includes programmers, and new languages designed for adding functionality in small components, like Java, make entry to the programming market much easier². But highly controlled centralized servers with no local computing power is not an environment that will encourage innovation.

To speak of deployment over 10 to 15 years is not realistic. 15 years ago, there were no windows-based personal computers, and a 5 Mbyte hard drive was an expensive luxury. Even the internet was not in wide use in 1980; the World Wide Web appeared less than 5 years ago. Today, a window-based personal computer faster than a mainframe of 1980 and with a 1 Gbyte disk can be had for about R5000.

Instead, short-term goals should be identified, and a plan for the next 5 years adopted. Even a 5-year plan has to make allowance for major unexpected innovations, and be open-ended in the way goals are specified.

The biggest risk in planning too far ahead is in committing to country-wide infrastructures such as networks, without a clear vision as to what will connect to them – and what people will eventually want to do. If we can decide the functionality, the technology will fall into place (at least to the extent that we can see far enough ahead). We cannot plan based on what we could buy today. The biggest strength of computer technology is the exponential improvement in what you can buy for your money (hyperinflation in reverse); the biggest weakness is the difficulty of upgrading fixed infrastructure such as networks, to keep

²To reiterate the obvious: the above is based on today's technology, the only certainty is that tomorrow's “Sumatra” will be orders of magnitude better!

up with general progress in other areas of computer technology.

Here are some examples of potential goals:

- give all schools access to a community centre with internet access by 2001
- aim to move from all centres in a region / province using the same server, to a server per resource centre over 5 years
 - training in server maintenance over that period will be required
 - at the same time, higher-level skills such as web page authoring and programming should become more widespread
- as funds permit, “terminals” should be gradually upgraded to full computer systems to permit local work such as word processing, recording lab experiments and programming
 - a strategy which assumes cheap internet “terminals” will quickly turn out to be too limiting
 - many “analysts” have proposed that there will be a massive market for such “terminals” but it seems likely that users will quickly discover that a fully fledged computer is still necessary
- design the infrastructure so that it is a relatively easy upgrade to improve the network bandwidth to at least HDTV standards, with potential for further upgrades to at least 1 Gbit/s
 - this can be achieved by a fibre optic backbone linking urban resource centres, with cheaper connections wherever the budget doesn’t permit the full fibre connectivity
 - the design should allow for upgrading to full fibre incrementally as funds become available (eventually to all urban schools)
 - rural areas will have to use radio or satellite links; the expense will preclude rapid deployment, but a 5-year time-frame may be realistic to cover at least the more populated areas
 - universities should be included in the network, so they become resources for the school system

By 2001, if a plan is adopted around the above goals, most school graduates will be very familiar with current technology, and we will have an infrastructure in place for adopting technologies of the next century. We should even have a base for contributing to innovation, rather than merely being consumers of technology.

3.7 Appropriate and Entrepreneurial Technology

Section 10.5 of the Green paper addresses the appropriate use of technology in marginalized and disadvantaged communities. Urban and rural communities of developing countries will clearly derive benefit from becoming the end users of first world technology and infrastructure, but, without local involvement, communities will become more (rather than less) reliant on foreign expertise, and less (rather than more) able to compete in a world technology market. Information Technology is an area in which a lo-

cal content and service industry can grow up, hand-in-hand with the installation of new infrastructure. The costs of setting up small enterprises in the Information Technology is much lower than in most other areas of Science and Technology.

Broadening the local content, and including previously marginalized groups, will require the working together of government, business, and institutions of higher education. South Africa is a substantial world market for Information Technology (estimates currently place us somewhere between 17th and 20th), and has considerable customer clout to avoid becoming a dumping ground for foreign technology.

Issue 10.6:

What should government do to motivate performers of SET to help provide effective solutions to improving the quality of life of the poor and marginalized?

....

Option 3

Institutional support is given specifically to the development of appropriate technology for community needs. In many cases the most useful methods will employ low or intermediate technology, but in some cases (for example, related to information and communication facilities), even in impoverished areas, high technology may be appropriate.

Collaborative ventures which combine technology transfer with local development require the support of political leaders, as well as entrepreneurs and educators. Forums such as the G7 ISAD conference (and others) are ideal platforms for taking a stand on this issue, and for encouraging foreign involvement in local Information Technology development.

Information Technology is an area in which high technology is often appropriate, even in impoverished areas. Institutional support for the development of appropriate technology is an obvious mechanism for encouraging the development of specific directions.

Section 10.6 of the Green paper addresses unemployment and opportunity. Information Technology is a field of Science and Technology which increasingly underpins other branches of SET, as well as every other field of professional endeavour. Information empowers people in their work place and in their private lives; access to Information Technology is essential in a modern society. IT in any economy must become a “driver” of the economy.

Issue 10.9:

How can curriculum design and educational strategies be utilised to create a technology-sensitive entrepreneurial culture and diffuse technical skills in the marginalized communities?

This can largely be done through existing educational institutions, provided they develop the appropriate courses in collaboration with local or overseas groups who have expertise in these areas.

Option 1

Existing secondary and tertiary educational institutions and NGOs are encouraged to design courses aimed at developing the required abilities in urban and rural communities. In particular, adult education centres, based in existing institutions or developed from scratch, are set up to provide suitable training, with both a technological and entrepreneurial character, for the unemployed population in the townships.

Information Technology will diffuse naturally into less developed communities if professionals working for private and government institutions in those communities take Information Technology into their work places as a natural means of becoming productive. This requires Information Technology skills to be spread far wider than traditional science and technology programmes, into the educational curricula of all professional directions. Government should accelerate this essential spread of Information Technology by providing incentives to educational institutions to turn out students with appropriate Information Technology skills to complement their chosen profession. At the very least, this would abate the number of graduates in low market related fields who are not readily absorbed into the job market.

In all areas of Science and Technology, but particularly in Information Technology, higher educational programmes would benefit substantially from the increased involvement of industry. Many institutions, including South Africa's technikons, have adopted the cooperative education model, incorporating practical work experience with academic study³. This ensures the marketability of graduates, and has a natural market tuning effect on curricula. A greater commitment from industry and educational institutions needs to be made in this direction. Government at all levels would play a key role through appropriate incentive schemes.

The only option mentioned in the Green paper under this section (option 1) is currently unsupported by Government. The tertiary educational sector needs to be given support for efforts that attempt to redress past inequalities, and that fall outside of their traditional roles. This is especially urgent for study directions in Science and Technology.

4 Conclusion

The vision of the Green paper is one of preparing South Africa for the 21st century. This vision is one of meeting the needs of individuals and communities through new solutions to problems: powerful solutions that leap-frog old obstacles. Such solutions depend upon innovation, that is, new discoveries that are effectively applied. This is clearly as much a social and economic vision as it is a scientific and technological one.

Legislation which eventually springs from the forth-

³Waterloo University in Canada has become world famous for this.

coming white paper must have an impact beyond the limits of arts, culture, science and technology if it is to be effective. Information technology innovation in particular must impact trade and industry and form an integral part of the strategy for the reconstruction and development of the country. Otherwise the greatest weakness of our science and technology, namely the limited capacity to convert scientific and technological advances into industrial and commercial innovations, will remain unaddressed.

Legislation should involve the implementation of various policies:

1. policy on support for SMMEs, this is broad but includes initiatives mentioned below in terms of community access centres and centres of excellence and expertise.
2. industrial policy to support information technology transfer, including general IT Development Coordination Point — Section 3.1.
3. regional and local IT deployment and IT infrastructure policy (including Community Access Centres, and Telecommunications and IT Infrastructure Coordination Point) — Section 3.1.
4. policy on the establishment of Centres of Expertise and Excellence in IT Innovation to support both SMME's and community access centres — Section 3.3.
5. national priority programme for information technology innovation in HES to support the South African information society, coupled with strategic support for human resources in IT at HES — Section 2.2.
6. coordinated certification for education and training in IT at non-university levels — Section 2.2.
7. competition policy covering intellectual property rights and standardization — Section 2.1.
8. HES-industry collaboration incentives (tax, offset) — Section 3.3.
9. HES-IT multinational cooperation — Section 3.4.

The white paper will have to identify and formulate the necessary measures which will develop the capacity for innovation in South Africa. The 21st century will be the century of the global information society. A substantial chapter of such proposals will have to deal with information technology and South Africa's preparation for the information age. The objective will be to see that IT will be enabled to provide better living conditions for all people more efficiently. Another objective must be to avoid a further deterioration of South Africa's competitive position in the face of increasing worldwide reliance on knowledge and IT for market advantage.

Appendix A Sections of the Green Paper with Passing References to IT

2.3 Policy Context

- 3.1 The Changing Role of Government in Support of the National System of Innovation
- 3.4 Toward the 21st Century
- 6.1 The International Experience
- 6.9 Information Infrastructure for SET Performers
- 7.8 The Regional and International Dimensions of Innovation
- 8.1 The Research and Development Orientation
- 9.3 The Appropriate Role of Technology in the Process of Learning Mathematics and Science at the Pretertiary Level
- 10.1 Technology and Public Choice: Sustainable Development and Ethical Issues
- 10.2 Impact of Technology on Democratisation
- 10.5 The Appropriate Use of Technology in Marginalized or Disadvantaged Communities

Appendix B Information Technology (IT) Policy in Australia

Anthony E Krzesinski, University of Stellenbosch

This appendix follows on from points raised earlier in Section 3.4.

IT products and services currently account for 20 percent of world trade and are growing at 10 percent per annum. The overall growth in world trade is 6 percent per annum: IT is an industry that no nation can afford to neglect.

The dynamic growth of the Asia/Pacific Region has led many corporations to re-focus their long-term strategies for the Region and for Australia. The mutual benefits are enormous: Australian firms provide specialized skills and techniques to help international companies win new niche markets, and in return international companies provide new markets for Australian products and services.

Corporations are encouraged to benefit from Australian innovations and advances in IT — Australia compares very favourably with other countries in the Region as a source of specialized IT skills, products and services. International companies bring the markets of the world to Australia's doorstep. They help Australian firms establish or expand their overseas markets through proven marketing and support networks. They provide immediate cost effective access to new technologies, innovative product development and improved economies of scale.

B.1 Partnerships for Development

Because of its geographic isolation from IT centres of the world, Australia was one of the first nations to become aware of the need to capture future IT opportunities. The Federal Government operates two schemes which encourage international companies to expand their strategic global activities in Australia and to seek out Australian products, services and skills with international prospects and mutually beneficial returns. These schemes are Partnerships for Development (PFD) and Fixed Term Arrangement (FTA) Programs.

PFD Program Partners agree to implement within 7 years strategic business plans to commercialize Australia's competitive strengths in the IT and communication industries. FTA Partners agree to a 4 year program. Partners only undertake activities that make commercial sense. The activities must be strategic and should be commercially sustainable after the Partnership expires.

Many of the world's leading IT companies participate in the programme. PFD Partners are: Alcatel, Amdahl, Apple, Bull, Cincom, DEC, Ericsson, Fijitsu, HP, IBM, Microsoft, NEC, Nokia, NorTel, Oracle, Pyramid, Siemens Nixdorf, Sun Microsystems, Tandem, Unisys and Wang. FTA Partners are: Acer, Canon, Compaq, Fuji Xerox, GPT, Hitachi Data Systems, Ingres, Oki Electric, Storage Technology, Toshiba and NCR. Some 300 Australian companies benefit from the PFD and FTA Programmes.

The policy is working. In 1987 Australia exported AU\$650 million of IT products and services. In 1991 this figure rose to AU\$1.5 billion, and by 1995 will have exceeded AU\$3 billion. By the year 2000 the IT industry is to become Australia's biggest employment and export sector.

B.2 Incentives to Collaboration

International companies with annual IT sales to government of between AU\$10–AU\$40 million are encouraged to enter into a FTA program. International companies with annual IT sales to government in excess of AU\$40 million are encouraged to enter into a PFD program. In practice this means that an international company that qualifies for PFD/FTA membership must allocate 15 percent of its sales to support the PFD/FTA program otherwise it cannot sell to government.

When entering into a PFD/FTA, the company undertakes to maintain a specified level of R&D and exports over a 7/4 year time frame. A business plan is drawn up in collaboration with the Commonwealth Department of Industry, Trade and Regional Development to determine how the PFD/FTA strategic activities complement the parent company's global business strategies, to identify potential local partners and to specify projects, activities and annual milestones.

The agreements are formalized in a Memorandum of Understanding between the Australian government, the international company's head office and the local subsidiary. Companies report annually on their progress as to how they have achieved the milestones specified in the business plan.

Australian companies are encouraged to become PFD/FTA partners by providing products, skills and services to international IT companies. Local companies must identify international IT partners, identify a mutually beneficial area of collaboration, understand the contractual arrangements required by the international partner, provide a detailed business, financial and marketing plan and investigate the international company's standards, quality control, volume, delivery and pricing procedures.

An external auditor provides an ongoing and consistent review of the effectiveness of the program. Partners are audited every two years at government expense and an

annual report is published by the auditors summarizing the effectiveness of the program.

B.3 Collaborative Research Centres

The Federal and State Governments encourage research collaboration between universities and industry. Government grants are available to develop Collaborative Research Centres (CRC's) to facilitate collaborations. After an initial period (usually 3 years) of government support, CRC's must be self funding from revenue raised from industry contracts. CRC's have ambitious goals and some of them already attract funding in excess of the competitive research funding available from the government.

As an example, the Centre for Information Technology Research Institute (CITRI) was established in 1990 by the Victorian State Government, the Royal Melbourne Institute of Technology (RMIT) and the University of Melbourne. CITRI hosts ±100 researchers (faculty members of the hosting institutions who double up as part-time associates in CITRI) and in 1993 earned AU\$7.3 million from industry contracts. CITRI hosts research groups which are active in telecommunications, database design, multimedia and neural networks. CITRI provides applications development, strategic research, consulting and training courses to industry. CITRI forms strategic alliances with large corporations to perform long term research in selected areas. For example, CITRI has an alliance with Ericsson Australia to develop a Software Engineering Research Centre (AU\$2 million over 5 years) focusing on performance analysis of Telecommunications Information Networking Architecture (TINA) and telecommunications software. CITRI has a successful track record in winning competitive research grants, developing generic research technologies and commercializing products. CITRI's education services include a Postgraduate Certificate in software engineering as well as courses designed for major engineering organizations.

CITRI provides facilities for postgraduate student training in its host departments of computer science and engineering.

B.4 Some Critical Remarks

Industry-university collaboration involves 3 partners: government, local and international companies and the universities. Government provides the legislative and financial incentives for industry and university to collaborate. This involves substantial expense in terms of the grants allocated to start up the many CRC's. On the other hand, university research funding has been reduced since Australian universities are expected to meet 40 percent of their budgets from outside sources that are facilitated by the CRC mechanism. Industry is collaborating: many international IT companies are members of the Partnerships for Development Programme. However, PFD membership often involves equipment discounts and donations of previous generation equipment rather than hard currency. Thus government and industry have met their obligations in terms of the PFD programme. It is essentially up to the universities to provide the manpower and skills to make the PFD programme work. However, few new university staff are appointed - academics are expected to maintain their current levels of teaching, research and administration and in addition to function as CRC associates. This may be possible: government may be of the opinion that Australian academics are not overworked and that they can become more productive.

It can be argued that the CRC mechanism is inconsistent with the university ethos and that the university's right to chose its areas of academic investigation was being restricted. Universities do not necessarily have the managerial and financial acumen to make a success of the CRC.

Received: March 1996

The Status of Computing Manpower and Training in Tertiary Education in Southern African Universities 1995

Judy M Bishop

Computer Science Department, University of Pretoria, Pretoria 0002
jbishop@cs.up.ac.za

Abstract

The survey of staff and student numbers done in 1992 provided the first country-wide picture of computing departments in South Africa. This report presents the picture three years later, from data collected in 1995. It categorises the 25 departments at universities into computer science and information systems and presents the figures comparatively with the 1992 survey. Full tables of all the data are given in the appendices and a novel feature of the 1995 survey is the inclusion of some technikons and universities from neighbouring states. The following factors are discussed: number of staff and posts; vacancies; secretarial and technical support; degree production at third year, honours, MSc and PhD levels; student performance in terms of first class passes and highest marks; qualifications of staff; and ratings by the Foundation for Research Development. The report ends with a look at a typical department. It concludes that not much has changed over the past few years. While there has been improvement in some critical factors, most departments remain too small and underqualified to be undertaking four year degrees and supervising postgraduates.

1 Introduction

Being in relatively young departments, computer science and information systems communities are continually having to motivate for more resources. They have no slack borne of earlier, easier times. In 1992, I conducted three surveys to establish the status of staff and student levels then. The emphasis was on finding the critical factors - how many posts were unfilled, how well qualified were the staff, how many higher degrees did we produce, how well did students perform at the top end of the scale - rather than on a comprehensive survey of all aspects of departmental life.

That survey was widely quoted and used, and now, three years on, it is time to update it. In order to provide an onward comparison, the questions were kept largely the same and the same issues were addressed. The complete results are given in the tables listed in Appendices A to F. What follows in this report is an analysis of the figures, highlighting trends and changes from 1992.

2 Survey Method

The three page questionnaire was sent out in May 1995 and replies were eventually received from all computer science and information systems departments in the country. A reply was received from the University of Qwa-Qwa but as they are only starting up, the figures are not included in what follows. The University of Zululand also teaches

computer science now as part of its Applied Mathematics activities, but was not polled this time. The Universities of Natal and Potchefstroom have two campuses each and these are handled as if they were separate institutions.

Six of the universities have two computing departments offering computer science in one, and information systems in another. Three universities have one department but differentiate between the two areas. In the tables that follow, I have listed the IS departments after the CS ones, and given each group's totals and averages separately. For the three joint departments, the student numbers appear separately in each group, and the staff numbers have been divided pro rata according to the student numbers, in order to make up the national totals. This is only an approximation, since the student numbers in question relate only to final years (third and honours).

In all, 19 campuses and 25 departments are represented in the survey. The departments in the sample are listed in Table 1.

In addition, the survey was sent to some technikons and universities in neighbouring states to obtain information for comparative purposes. Thus the Appendices provides the figures for six Technikons and four outside universities listed in Table 2.

3 Staff and posts

As shown in Table 3, there has been a 10% increase in staff in computer science departments over the past three years,

Table 1. Surveys received

Cape Town - CS
Cape Town - IS
Durban-Westville - CS
Durban-Westville - IS
Fort Hare
Natal Durban - CS
Natal Durban - BIS
Natal, P'burg - CS and IS
North - CS and IS
Orange Free State
Port Elizabeth
Potchefstroom
Potchefstroom (Vaal)
Pretoria - CS
Pretoria - Inf
Rand Afrikaans
Rhodes - CS
Rhodes - IS
Stellenbosch
Transkei
Unisa - CS and IS
Vista
Western Cape
Witwatersrand - CS
Witwatersrand - IS

Table 2. Additional surveys received

ML Sultan Technikon
Orange Free State Technikon
Northern Transvaal Technikon
Technikon SA
Vaal Triangal Technikon
Witwatersrand Technikon
University of Malawi, Chancellor College, Zomba
University of Namibia
National Univ. of Science and Technology, Bulawayo
University of Zimbabwe, Harare

which really is very little. Moreover, the average number of staff per department has stayed at about 6, which is certainly not a critical mass for a department required to offer courses all the way to PhD level. The fact that the small increase has been almost entirely at lecturer level is also a cause for concern.

The number of actual posts in computer science is a little higher at 7.6 on average, indicating 12% vacancies across the board. The vacancies are, however, very much skewed towards the historically disadvantaged universities, with Fort Hare at 3 (60%), the North at 3 (33%) and Vista at 4 (31%). At the time of the survey, half of the departments had no vacancies, viz: Pietermaritzburg, Port Elizabeth, Potchefstroom (Vaal), Pretoria (CS and IS), Rand Afrikaans, Rhodes (CS and IS), Stellenbosch, Transkei,

Cape Town (IS), Durban-Westville (IS) and Natal-Durban (IS).

In information systems, a new department has opened in Durban-Westville, and Natal Pietermaritzburg and the University of the North are now giving full BIS degrees. Table 3 shows an overall increase in staff nationwide over the past three years as 125% and the average staff in departments increasing from 5 to 8. We notice that increases in staff have occurred evenly across all levels of seniority.

The small increase in computer science and the huge jump in information systems staff is in part explained by the change in the way in which the staff numbers of combined departments (especially Unisa) are now tallied. Previously, all staff were counted under computer science. Now they are split pro rata on student numbers.

While it is tempting to jump to the conclusion that computer science is suffering at the expense of information systems, which is undoubtedly becoming popular, the situation is actually far more complex. Computer science and information systems departments are in different faculties – science and commerce, respectively. Other science departments such as physics and chemistry have seen their student numbers shrinking over the period in question, and as a result, science faculties as a whole have had their budgets remain static or even reduced. Since redundancies are not widely practiced at universities, these older departments retain their staff, with the result that the departments that have shown a significant growth in student numbers are blocked from expanding. It is a common complaint among heads of computer science departments that their requests for more staff are each year turned down because the faculty as a whole is over-staffed.

On the other hand, commerce departments seem to be generally in an expansionist phase, and the huge numbers of accounting students being taught basic computing skills draw in extra staff fairly routinely. It is unlikely that computer science departments would wish to return to the days of large service teaching classes, but the time may well be right to start investigating whether they would fare better outside of science faculties.

An interesting contrast is provided by the six technikons studied. The number of staff posts allocated to these departments is higher than the universities – 12 on average.

The number of departments which have a ratio of more than 1.4 (professors + associate professors + senior lecturers) to (lecturers + junior lecturers) has increased over the three years to nine out of 25 surveyed. The 1.4 figure is that which is recommended by SAPSE norms, and the fact that only a third of the departments can attain it is indicative of a problem. The departments which have maintained a high ratio of senior staff, or have now achieved one are shown in Table 4

Vacancies in the computer science departments at universities are running at one per department or 12%. No comparative figures are available for 1992. In IS, there is actually a glut of staff. In the technikons, the vacancy figure is up to 1.4 per department.

Table 3. Number of staff in academic posts country wide

		Depts	P	A	S	L	J	Total	Ave.	Change
CS	1992	18	23	12	32	37	6	110	6.1	
	1995	19	23	12	33	48	11	127	6.7	+10%
IS	1992	6	3	3	10	12	4	32	5.3	
	1995	9	8	8	27	23	5	72	8.0	+125%

P Professor
A Associate professor
S Senior lecturer
L Lecturer
J Junior lecturer

Table 4. SAPSE staff level ratios (P+A+S:L+J) > 1.4

	1992	1995
Pretoria - CS	7.0	8.0
Natal Durban CS	no return	8.0
Rand Afrikaans	5.0	6.0
Cape Town - CS	8.0	3.5
Cape Town - IS	1.3	3.0
Natal Durban - BIS	4.0	3.0
Witwatersrand - CS	0.8	2.0
Witwatersrand - IS	0.4	1.7
Orange Free State	1.0	1.5

Table 5. Degree production compared over three years

	1991	1994	'94 Ave.	Change
CS	Departments	16	19	
	Third year	712	695	39
	Honours	172	176	10
CS	Departments	4	6	
	Third year	462	489	57
	Honours	78	96	7

Secretarial staff is running at one secretary on average for a complement of 7.6 posts. IS is better off with 1.3 secretaries for 8.1 posts on average. The technikons have a poorer ratio - 1.3 secretaries for their 12.4 posts.

Technical staff across the universities and technikons is set at an average of 1.4 per department, though this figure is somewhat skewed by the high number of staff (four) reported for Vista, Western Cape, Vaal Triangle Technikon and Witwatersrand Technikon. One technician is really the norm.

The full figures for staff, posts and people are given in Appendix A.

4 Degree Production

One of the most unexpected results of the survey is that the number of degrees produced in both areas has not changed much, except in the case of honours degrees in information systems. On the other hand, there is now a sizeable number of third year graduates coming out of technikons - more than the average university computer department produces. This is to be expected since the technikons also have more staff. Table 5 shows the comparative figures. Note that in 1991 two universities (Natal Durban CS and Rand Afrikaans) did not submit returns, so that their figures have been estimated and recorded in italics in Appendix B.

In the previous survey, I identified big departments and small departments, depending on the number of graduates. Of the 25 CS or IS departments surveyed now, eight (one

third) had more than 50 graduates last year. Together these departments (in five universities) produced 64% of the three year degrees, and 68% of the honours degrees. While one cannot argue the value of having computer science and information systems widely spread at bachelors level, it is debatable whether we can continue to put staff time into running honours programmes at every one of the other 17 departments. Table 6 gives the picture.

Table 6. Degrees produced by the most prolific eight departments (CS and IS)

	Third year		Honours	
	1991	1994	1991	1994
Unisa - IS	183	204	6	15
Rand Afrikaans	100	105	15	17
Cape Town - IS	72	86	31	24
Witwatersrand - CS	76	69	21	21
Unisa - CS	147	68	17	11
Potchefstroom	46	65	10	9
Cape Town - CS	54	63	25	26
Pretoria - CS	45	50	26	27
Witwatersrand - IS	50	49	16	
Total	773	759	151	166
Percentage of total	66%	64%	66%	68%

A new indicator of degree production is a comparison of the number of undergraduate degrees produced to the number of staff. On this scale, the results are quite diverse. RAU produces 20 degrees per member of staff. Unisa, Wits CS and Cape Town (CS and IS) about half that, and all other departments are more in the region of 4-8 degrees per member of staff per year.

This production rate, which is significantly lower than

the usual staff:student ratio of 1:14, can be explained in two ways:

- either staff are engaged on large amounts of service teaching and academic support programmes, and only spend some of their time producing computer science or information science graduates per se;
- or the throughput from first year to second year and finally to graduation is slow, and staff are spending large amounts of time on students who don't eventually make it.

5 Student Performance

Following on from production, we can look at the performance of students. Specifically, we consider the number of first class passes awarded at third and honours level. These figures are becoming increasingly approximate, with many universities working on a module system now. However, heads were asked to average over modules and at least give an indication of how their students fare.

The results were interesting. In 1994, 16% of computer science students achieved firsts in three year degrees and 24% in honours. The figures for 1991 were similar. However, in 1994, four departments awarded considerably more firsts, viz.

	Students	Firsts	Achieving firsts
Rand Afrikaans	105	40	38%
Transkei	7	2	29%
Pretoria - CS	50	14	28%
Witwatersrand - CS	69	18	26%

It is to be noted that the usual percentage of firsts at British universities is 13%, but many of the prestigious old schools award a higher number, such as 20% at Cambridge.

At honours level, significantly higher rates were given in 1994 by Orange Free State, Rhodes, Rand Afrikaans, Western Cape and Witwatersrand - CS. However, the numbers in honours are too small to make significant statements.

In the information systems departments, the picture is very different, with only 5% of students being awarded firsts in their bachelors degrees and 12% at honours level. Cape Town and Rhodes have the highest ratio, at 13% each.

Departments were once again asked to state their highest mark awarded and, generally, the marks given in 1994 were higher than those in 1991. Over all degrees, there were ten departments that awarded their top students with final marks in the nineties, compared to three previously.

Student performance is summarised in Appendix C.

6 Postgraduate Training

Appendices D and E show the full figures for postgraduate degrees awarded since the last survey, but the numbers are so small in most cases that I shall only deal in country-

wide totals here. Overall, the number of masters degrees produced is not increasing, hovering at around the 35-40 per year mark, but the number of doctorates is going up, which is encouraging.

Table 7. Postgraduate degrees awarded (CS and IS), together with registrations

	Awarded		Registered	
	Masters	PhD	Masters	PhD
1990	29	3		
1991	37	3		
1992	36	7	181	45
1993	49	6		
1994	36	6		
1995			301	61
Total	135	24		

The technikons and neighbouring universities have not yet produced higher degrees yet, although two (ML Sultan and Technikon Witwatersrand) have now registered students for the MTec.

A new indicator is the number of higher degrees produced per member of staff qualified to do so (i.e. with a masters or doctorate). There are only four departments which over the past three years have produced more than half a postgraduate degree per qualified staff member¹.

These are shown in Table 8.

It is interesting to reflect that additional funding is not always a sufficient stimulation for more higher degrees. Over the 1992-1994 period, three universities were chosen by the Foundation for Research Development to receive special grants to enable them to increase their research capacity and their output of postgraduates. Of these, Rand Afrikaans and Rhodes feature in Table 8, but the University of Cape Town (with an average production of 0.25) does not. Wits received no additional funding over this period, and Pretoria was given a small amount in 1994.

Table 8. Higher degrees produced per qualified staff member (PhD or M) from 1992-1995

	Higher Degrees	Staff	3 year ratio
Rand Afrikaans	39	6	2.17
Pretoria - CS	13	6	0.72
Witwatersrand - CS	16	8	0.67
Rhodes - CS	12	8	0.50

7 Staff Qualifications

The level of qualifications of staff has improved slightly in information systems over the past few years, but in com-

¹Potchefstroom (Vaal) has a very high ratio in Appendix E, but this is explained by there being only one qualified person left this year: there used to be four, who would have been involved with the supervision of the 7 MSc degrees produced.

puter science it has got worse rather than better, as shown in full in Appendix F and summarized in Table 9. Once again, the staff numbers for Pietermatritzburg, North and Unisa have been allocated pro rata according to students.

Table 9. Staff qualifications and those still studying for Masters or PhD

		PhD	Masters	Honours	Registered for a degree
CS	1992	47	48	19	26
	1995	46	54	19	37
IS	1992	12	24	28	17
	1995	15	38	23	18

In terms of a ratio of PhD+Masters to total staff, the six departments shown in Table 10 come out at 1.00, i.e. all staff have more than an honours degree.

Table 10. Departments with high staff qualification ratios

	PhD	M
Natal - P'burg	4	3
Natal - Durban - CS	2	1
Rand Afrikaans	6	
Stellenbosch	4	4
Transkei	4	
Witwatersrand - CS	7	1

The worrying evidence of this ratio is that it has declined from 0.85 in 1992 to 0.82 in 1995. More underqualified staff are being employed and are having to complete their studies on the job. Though perhaps born of desperation, the wisdom of this practice must be questioned.

Regarding the issue of overseas and local PhDs, some respondents asked whether this had any relevance. The purpose of keeping these figures is to establish the extent to which the country is training its own people to take up academic positions.

Table 11. CS and IS academics with PhDs

	Overseas PhD	Local PhD	Total
1992	25	34	59
1995	25	35	60

Table 11 tells it all. Bearing in mind that 22 PhDs were produced over the past five years, it can be seen that there is no net inflow of these qualifications into the universities. Some of the graduates may indeed have joined departments, but they have been matched by staff who have left to emigrate or join industry. Either way, departments are not being enriched by the production of PhDs.

In terms of considering the subject in which degrees are obtained, there is some good news. The percentage of staff qualified with their highest degree in computer science is 87%, and in information system degrees is 70%².

²These figures are not shown in the appendices.

8 FRD Ratings

The new funding policy of the Foundation for Research Development which has been introduced in 1996 requires a rating for any principal grant holder. To obtain a rating, a scientist must undergo a rigorous peer review process, which is then valid for four years before having to be renewed. Hundreds of scientists and engineers are rated in this way every year.

Table 12. FRD ratings in 1995

Cape Town - CS	6
Rand Afrikaans	4
Orange Free State	2
Pretoria - CS	2
Witwatersrand - CS	2
Stellenbosch	1
Durban-Westville	1
Rhodes - CS	1
Total	19

Of the 48 computer scientists with PhDs in universities, only 19 (40%) had ratings in 1995. This figure was up from 12 in 1992, so progress is being made. It is also likely that a few more came through in the 1995 round.

9 Conclusions

In South Africa, computer science is offered at 19 universities and information systems in nine. Only Transkei at present does not go on to offer honours or masters degrees. The typical country-wide profile of a department is illustrated in table 13

Overall, the picture is not a very encouraging one. Six staff is simply not a critical number to run a full four year programme, do service teaching and supervise postgraduates. The fact that the same universities keep coming up at the top of the tables is indicative that with more staff, better conditions, and better qualifications, more can be done. However, the less fortunate universities are suffering, and the question is to what extent their students are suffering too. This survey does not in any way address such a difficult question, but it begs it, and at some stage the South African computing community should look for the answer, and decide on appropriate action.

Acknowledgements: I would like to thank the heads and secretaries of all the departments for cooperating in returning the forms. Without them, there would be no results and no report.

Received: 2/96

Table 13. The typical country-wide profile of a department

	CS	IS	
staff members	6.7	8.0	
% increase over 1992	10%	125%	
vacancies	1	0	
secretaries	1.0	1.3	
technicians	1.4	0.8	
SAPSE ratio average	1.8	1.7	
third year graduates	42	65	
% increase over 1992	-2%	6%	
honours graduates	10	16	
% increase over 1992	2%	23%	
graduates per staff member	6.7	8.1	
firsts at third year level	16%	5%	
firsts at honours level	24%	12%	
highest mark at third level	83	77	
highest mark at honours level	82	78	
Masters degrees per year	2.1	1.6	(13 and 4 depts)
PhD degrees per year	0.43	2	(8 and 1 depts)
higher degrees per staff member	0.55	0.74	
staff registered for higher degree	2.47	3.60	
staff with PhD	3	2	
staff with MSc	3	4	
staff with Hons	1	3	
staff qualified in subject	87%	70%	
FRD ratings	1	n/a	

1995 CS/IS Survey – Appendix A. Staff and Posts

Department	Institution	Professors	Assoc. Professors	Senior Lecturers	Lecturers	Junior Lecturers	Total academic staff	SAPSE ratio	Total academic posts	Vacancies	Secretaries	Technical staff
Computer Science												
Comp Sci and BIS	Natal, P'burg – both staff		1	3	3		7.0	1.3	7	0	1	1
Comp Sci and Inf Sys	North – both staff	1	1	1	2	1	6.0	1.0	9	3	0.3	1
Comp Sci and Inf Sys	UNISA – both staff	3	2	11	12		28.0	1.3	33	5	5	1
Computer Science	Cape Town – CS	2	2	3	2		9.0	3.5	10	1	2.5	1.3
Computer Science	Durban-Westville		1	1	2.5	1	5.5	0.6	5	-1	1	2
Computer Science	Fort Hare			1	1		2.0	1.0	5	3	0	1
Computer Science	Natal Durban – CS	1	1	2	0	0.5	4.5	8.0	6	2	1	1
Computer Science	Natal, P'burg – CS	0	1	2	2	0	3.7	1.3	3.7	0	0.5	0.5
Computer Science	North – CS	1	1	1	2	1	5.1	1.0	7.6	3	0.2	0.8
Computer Science	Orange Free State	1	1	2.5	2	1	7.5	1.5	8.5	1	0.5	1
Computer Science	Port Elizabeth	2		3	3	2	10.0	1.0	10	0	0.5	3
Computer Science	Potchefstroom	1	1	1	5	1	9.0	0.5	10	1	0.5	0.5
Comp Sci and Inf Sys	Potchefstroom (Vaal)				2	1	3.0	0.0	3	0	0	0
Computer Science	Pretoria – CS	4	1	3	1		9.0	8.0	9	0	1.5	2
Computer Science	Rand Afrikaans	4		2			6.0		6	0	1	0
Computer Science	Rhodes – CS	2	1		4.5	0.5	8.0	0.6	8	0	1	1
Computer Science	Stellenbosch	1	1	1	3	1	7.0	0.8	7	0	1	1
Computer Science	Transkei		1	1	2	1	5.0	0.7	5	0		
Computer Science	UNISA – CS	1	1	3	3	0	7.4	1.3	8.7	1	1.3	0.3
Comp Sci and Inf Tech	Vista, Pretoria	1			8		9.0	0.1	13	4	1	4.5
Computer Science	Western Cape	1		2	4		7.0	0.8	8	1	1	4
Computer Science	Witwatersrand – CS	1		5	2	1	9.0	2.0	10	1	1	3
	Total	23	12	33	48	11	126.7		144	17	22	30
	Average	1.5	1.0	2.1	2.7	0.8	6.7	1.8	7.6	0.9	1.0	1.4
Information Systems												
Information Systems	Cape Town – IS	1	2	4.5	2.5		10.0	3.0	10	0	2	2
Business Inf Sys	Durban-Westville – BIS		1	1			2.0		2	0		1
Business Inf Sys	Natal, Durban – BIS	1		2	1		4.0	3.0	3	-1	0.5	1
Business Inf Sys	Natal, P'burg – BIS	0.0	0.5	1.4	1.4	0.0	3.3	1.3	3.3	0	0.5	0.5
Information Systems	North – IS	0.2	0.2	0.2	0.3	0.2	0.9	1.0	1.4	0	0.0	0.2
Informatics	Pretoria – Inf	2	1	5	4	4	16.0	1.0	12.5	-4	1	1
Business Inf Sys	Rhodes – BIS	1	1	2	3	0	7.0	1.3	7	0	1	1
Information Systems	UNISA – IS	2.2	1.5	8.1	8.8	0	20.6	1.3	24.3	4	3.7	0.7
Information Systems	Witwatersrand – IS	1	1	3	2	1	8.0	1.7	9	1	1.5	0
	Total	8	8	27	23	5	71.8		72	1	10	7
	Average	1.0	1.0	3.0	2.9	0.9	8.0	1.7	8.1	0.1	1.3	0.8
Technikons												
Computer Studies	ML Sultan		1	3	10		14.0	0.6	17	3	1	1
Business School	Northern Transvaal			2	5		7.0	0.5	11	4	1	1
Computer Data Proc	Orange Free State	1	2	2	11		16.0	0.9	14.5	-1.5	1.5	0.8
Information Technology	Technikon SA			4	5	0.5	9.5	0.6	13	3.5	1	1
Computer Tech.	Vaal Triangle	1	6				7.0	1.4	7	0	2	4
School for IT	Witwatersrand		2	4	4	1	11.0	0.8	12	1	1	4
	Total	2	11	15	35	2	65		75	10	8	12
	Average	1.0	2.8	3.0	7.0	0.8	10.8	0.7	12.4	1.7	1.3	2.0
External												
Computer Science	Zimbabwe, Harare	1		12			6.0	1.1	13	7	2	0
Computer Science	NUST, Bulawayo		2		3		5.0	0.9	5	0	2	1
Comp Sci and Soc Sci	Malawi, Zomba			1	3	1	4.0	0.7	5	1	0	3
Computing	Namibia			1	1		2.0	0.6	3	1	0	1
	Total	1	2	14	7	1	17.0		26	9	4	5
	Average	1.0	2.0	4.7	2.3	1.0	4.3	0.8	6.5	2.3	1.0	1.3

1995 CS/IS Survey – Appendix B. Degree Production

Department	Institution	Graduated third year 1991	Graduated third year 1994	Registered third Year 1995	Graduated Hons 1991	Graduated Hons 1994	Registered Hons 1995	Degree Production Ratio 1994
Computer Science								
Comp Sci and BIS	Natal, P'burg – both staff							1.9
Comp Sci and Inf Sys	North – both staff							3.2
Comp Sci and Inf Sys	UNISA – both staff							3.0
Computer Science	Cape Town – CS	54	63	49	25	26	29	9.9
Computer Science	Durban-Westville	23	28	34		5	11	6.0
Computer Science	Fort Hare	21	7	7	1	0	0	3.5
Computer Science	Natal Durban – CS	25	25	25	7	7	6	7.1
Computer Science	Natal, P'burg – CS	14	13	14	10	9	5	6.0
Computer Science	North – CS	13	19	27	5	3	2	4.3
Computer Science	Orange Free State	28	38	48	3	3	17	5.5
Computer Science	Port Elizabeth	30	36	42	10	10		4.6
Computer Science	Potchefstroom	45	65	65	10	9	25	8.2
Comp Sci and Inf Sys	Potchefstroom (Vaal)	22	12	18	6	2	0	4.7
Computer Science	Pretoria – CS	45	50	42	26	27	45	8.6
Computer Science	Rand Afrikaans	100	105	93	15	17	39	20.3
Computer Science	Rhodes – CS	24	25	24	7	12	14	4.6
Computer Science	Stellenbosch	25	40	40	9	11	12	7.3
Computer Science	Transkei		7	65				1.4
Computer Science	UNISA – CS	147	68	212	17	11	29	10.6
Comp Sci and Inf Tech	Vista, Pretoria			7				0.0
Computer Science	Western Cape	20	25	45		3	0	4.0
Computer Science	Witwatersrand – CS	76	69	67	21	21	23	10.0
	Total	712	695	924	172	176	257	
	Average	41.9	38.6	48.6	11.5	10.4	16.1	6.7
Information Systems								
Information Systems	Cape Town – IS	72	86	115	31	43	44	12.9
Business Inf Sys	Durban-Westville – BIS		32	55				16.0
Business Inf Sys	Natal, Durban – BIS	53	22	32	2	3	3	6.3
Business Inf Sys	Natal, P'burg – BIS		20	26				6.0
Information Systems	North – IS	4	4	7				4.3
Informatics	Pretoria – Inf	66	40	69	14	14	21	3.4
Business Inf Sys	Rhodes – BIS	26	32	38	4	5	10	5.3
Information Systems	UNISA – IS	183	204	302	6	15	76	10.6
Information Systems	Witwatersrand – IS	50	49	54		16	9	8.1
	Total	454	489	698	57	96	163	
	Average	64.9	54.3	77.6	11.4	16.0	27.2	8.1
Technikons								
Computer Studies	ML Sultan		30	35		1	20	2.2
Business School	Northern Transvaal		37	19				5.3
Computer Data Proc	Orange Free State		37	115		1	6	2.4
Information Technology	Technikon SA							
Computer Tech.	Vaal Triangle		22	24		0	7	3.1
School for IT	Witwatersrand		73	90		30	30	9.4
	Total		199	283		32	63	
	Average		39.8	56.6		8.0	15.8	4.5
External								
Computer Science	Zimbabwe, Harare		28	35				4.7
Computer Science	NUST, Bulawayo							0.0
Comp Sci and Soc Sci	Malawi, Zomba		36	21		23	27	14.8
Computing	Namibia		5	3				2.5
	Total		69	59		23	27	22
	Average		23.0	19.7		23.0	27.0	5.5

1995 CS/IS Survey – C. Student Performance

Department	Institution	Firsts in third year 1994	Top third year mark 1994	Ratio of firsts in third year 1994	Firsts in Hons 1994	Top Hons mark 1994	Ratio of firsts in hons 1994
Computer Science							
Comp Sci and BIS	Natal, P'burg – both staff						
Comp Sci and Inf Sys	North – both staff						
Comp Sci and Inf Sys	UNISA – both staff						
Computer Science	Cape Town – CS	8	87	0.13	7	90	0.27
Computer Science	Durban-Westville	1	75	0.04	1	82	0.20
Computer Science	Fort Hare	0	63	0.00			
Computer Science	Natal Durban – CS						
Computer Science	Natal, P'burg – CS	1	75	0.08	1	79	0.11
Computer Science	North – CS	0	66	0.00	0	65	0.00
Computer Science	Orange Free State	7	86	0.18	1	80	0.33
Computer Science	Port Elizabeth	6	85	0.17	2	80	0.20
Computer Science	Potchefstroom		88	0.00		92	
Comp Sci and Inf Sys	Potchefstroom (Vaal)	1	79	0.08	0		0.00
Computer Science	Pretoria – CS	14	98	0.28	5	82	0.19
Computer Science	Rand Afrikaans	40	93	0.38	7	85	0.41
Computer Science	Rhodes – CS	4	80	0.16	6	84	0.50
Computer Science	Stellenbosch	3	80	0.08	2	86	0.18
Computer Science	Transkei	2	92	0.29			
Computer Science	UNISA – CS	5	92	0.07	2	76	0.18
Comp Sci and Inf Tech	Vista, Pretoria						
Computer Science	Western Cape	1	91	0.04	1	90	0.33
Computer Science	Witwatersrand – CS	18	86	0.26	8	90	0.38
	Total	111			43		
	Average	6.2	83.1	0.16	2.7	82.4	0.24
Information Systems							
Information Systems	Cape Town – IS	11	82	0.13	6	82	0.14
Business Inf Sys	Durban-Westville – BIS	2	80	0.06			
Business Inf Sys	Natal, Durban – BIS	0	73	0.00	0	72	0.00
Business Inf Sys	Natal, P'burg – BIS	1	75	0.05			
Information Systems	North – IS	0	60	0.00			
Informatics	Pretoria – Inf	4	77	0.10	1	77	0.07
Business Inf Sys	Rhodes – BIS	4	80	0.13	1	77	0.20
Information Systems	UNISA – IS	4	91	0.02	3	81	0.20
Information Systems	Witwatersrand – IS	0	72	0.00	4		
	Total	26			15		
	Average	2.9	76.67	0.05	2.50	77.80	0.12
Technikons							
Computer Studies	ML Sultan	12	84	0.34	1	64	0.02
Business School	Northern Transvaal						
Computer Data Proc	Orange Free State						
Information Technology	Technikon SA						
Computer Tech.	Vaal Triangle	0	73	0.00			
School for IT	Witwatersrand	20	88	0.22	10	90	0.11
	Total	32			11		
	Average	10.7	81.7	0.2	5.5	77.0	0.1
External							
Computer Science	Zimbabwe, Harare	3	88				
Computer Science	NUST, Bulawayo						
Comp Sci and Soc Sci	Malawi, Zomba					65	
Computing	Namibia	1	75				
	Total	4	163				
	Average	2.0	81.5			65.00	

1995 CS/IS Survey – Appendix D. Postgraduate Registration

Department	Institution	Masters 1992	Masters 1993	Masters 1994	Masters 1995 so far	Masters 1992-1995	PhDs 1992	PhDs 1993	PhDs 1994	PhD 1995 so far	PhDs 1992-1995
Computer Science											
Comp Sci and BIS	Natal – P'burg – both staff										
Comp Sci and IS	North – both staff										
Comp Sci and Inf Sys	UNISA – both staff										
Computer Science	Cape Town – CS	2	2	1	0	5	0	1	0	0	1
Computer Science	Durban-Westville – CS										
Computer Science	Fort Hare										
Computer Science	Natal Durban – CS									0	
Comp Science	Natal – P'burb – CS	2	0	1	1	4	1	0	0	0	1
Computer Science	North – CS	1	0	0	0	1					
Computer Science	Orange Free State	0	0	0	1	1	1	0	1	0	2
Computer Science	Port Elizabeth	0	2	2	0	4	0	0	0	1	1
Computer Science	Potchefstroom	1	0	1	2	4	0	2	0	1	3
Comp Sci and Inf Sys	Potchefstroom (Vaal)	2	3	1	1	7					
Computer Science	Pretoria – CS	4	4	1	4	13					
Computer Science	Rand Afrikaans	9	17	6	3	35	1	0	2	1	4
Computer Science	Rhodes – CS	4	3	4	0	11	0	1	0	0	1
Computer Science	Stellenbosch	2	2	3	0	7	0	0	1	1	2
Computer Science	Transkei										
Computer Science	UNISA – CS	0	2	1	0	3	0	1	1	0	2
Comp Sci & Inf Tech	Vista, Pretoria	0	2	2	0	4					
Computer Science	Western Cape										
Computer Science	Witwatersrand – CS	5	5	3	2	15	0	0	0	1	1
	Total	32	42	26	14	114	3	5	5	5	18
	Average	2.3	3.0	1.9	1.0	8.1	0.3	0.5	0.5	0.5	1.8
Information Systems											
Information Systems	Cape Town – IS	2	2	1	0	5					
Business Inf Sys	Durban-Westville - BIS										
Business Inf Sys	Natal Durban – BIS										
Information Systems	North – IS										
Business Inf Sys	Pietermaritzburg – BIS										
Informatics	Pretoria – Inf	2	1	6	0	9	4	1	1	0	6
Business Inf Sys	Rhodes – BIS										
Information Systems	UNISA – IS	0	2	2	0	4					
Information Systems	Witwatersrand – IS	0	0	1	2	3					
	Total	4	5	10	2	21					6
	Average	1.0	1.3	2.5	0.5	5.3	4.0	1.0	1.0	0.0	6
Technikons											
Computer Studies	ML Sultan										
Business School	Northern Transvaal										
Computer Data Proc	Orange Free State										
Information Technology	Technikon SA										
Computer Tech.	Vaal Triangle										
School for IT	Witwatersrand				1						
	Total										
	Average										
External											
Comp Sci and Soc Sci	Malawi, Zomba										
Computing	Namibia										
Computer Science	NUST, Bulawayo										
Computer Science	Zimbabwe, Harare										
	Total										
	Average										

1995 CS/IS Survey – Appendix E. Postgraduate Production

Department	Institution	Masters 1992-1995	Masters registered 1995	PhDs registered 1995	Staff regist- ered for higher degrees 1995	Higher degrees produced per staff member with Phd or MSc over 3 years
Computer Science						
Comp Sci and BIS	Natal – P'burg – both staff					
Comp Sci and IS	North – both staff					
Comp Sci and Inf Sys	UNISA – both staff					
Computer Science	Cape Town – CS	5	17		1	0.25
Computer Science	Durban-Westville – CS		2		2	0.00
Computer Science	Fort Hare					
Computer Science	Natal Durban – CS		7	1		
Comp Science	Natal – P'burb – CS	4	11		3	0.24
Computer Science	North – CS	1	3		3	0.08
Computer Science	Orange Free State	1	3	1	0	0.17
Computer Science	Port Elizabeth	4	10	2	5	0.21
Computer Science	Potchefstroom	4	5	2	3	0.26
Comp Sci and Inf Sys	Potchefstroom (Vaal)	7	11		2	2.33
Computer Science	Pretoria – CS	13	28	6	2	0.72
Computer Science	Rand Afrikaans	35	25	17	0	2.17
Computer Science	Rhodes – CS	11	7	8	2	0.50
Computer Science	Stellenbosch	7	17	5	3	0.38
Computer Science	Transkei					
Computer Science	UNISA – CS	3	15	6	8	0.07
Comp Sci & Inf Tech	Vista, Pretoria	4				0.22
Computer Science	Western Cape		2		2	
Computer Science	Witwatersrand – CS	15	26	2	1	0.67
	Total	114	189	50	37	0.44
	Average	8.14	11.81	5.00	2.47	0.59
Information Systems						
Information Systems	Cape Town – IS		12		3	0.28
Business Inf Sys	Durban-Westville - BIS					
Business Inf Sys	Natal Durban – BIS		2		2	
Information Systems	North – IS					
Business Inf Sys	Pietermaritzburg – BIS					
Informatics	Pretoria – Inf		11	11	6	0.45
Business Inf Sys	Rhodes – BIS					
Information Systems	UNISA – IS		16		2	0.06
Information Systems	Witwatersrand – IS		71		5	0.17
	Total		112	11	18	0.17
	Average		22.40	11.00	3.60	0.61
Technikons						
Computer Studies	ML Sultan		4			
Business School	Northern Transvaal					
Computer Data Proc	Orange Free State					
Information Technology	Technikon SA					
Computer Tech.	Vaal Triangle					
School for IT	Witwatersrand		1		1	
	Total		5		1	
	Average					
External						
Comp Sci and Soc Sci	Malawi, Zomba					
Computing	Namibia					
Computer Science	NUST, Bulawayo					
Computer Science	Zimbabwe, Harare					
	Total					
	Average					

1995 CS/IS Survey – Appendix F. Staff Qualifications

Department	Institution	Total staff with PhDs 1992	Staff with Masters 1992	Staff with Hons 1992	Total staff with PhDs 1995	Staff with Masters 1995	Staff with Hons 1995	Departmental qualification factor 1992	Departmental qualification factor 1995
Computer Science									
Comp Sci and BIS	Natal – P'burg – both staff	3	3	2	4	3	0	0.67	1.00
Comp Sci and IS	North – both staff	2	2	1	2	2	2	0.80	0.67
Comp Sci and Inf Sys	UNISA – both staff	6	11	9	6	18	4	0.65	0.86
Computer Science	Cape Town – CS	7	1	1	6	2	1	0.89	0.89
Computer Science	Durban-Westville – CS	3	1	0	2	2	1	1.00	0.80
Computer Science	Fort Hare	1	1	0		1	1	1.00	0.50
Computer Science	Natal Durban – CS	2	4	0	2	1		1.00	1.00
Comp Science	Natal – P'burb – CS	1	1	1	2	1	0	0.75	1.00
Computer Science	North – CS	1	1	0	1	1	1	0.80	0.67
Computer Science	Orange Free State	3	3	2	4	2	2	0.75	0.75
Computer Science	Port Elizabeth	1	7	1	1	7	2	0.89	0.80
Computer Science	Potchefstroom	2	5	2	2	7	1	0.78	0.90
Comp Sci and Inf Sys	Potchefstroom (Vaal)	1	3	0	1	0	2	1.00	0.33
Computer Science	Pretoria – CS	4	2	1	4	2	2	0.86	0.75
Computer Science	Rand Afrikaans	6	0	0	6	0	0	1.00	1.00
Computer Science	Rhodes – CS	3	5	0	3	5	1	1.00	0.89
Computer Science	Stellenbosch	3	5	4	4	4	0	0.64	1.00
Computer Science	Transkei					4			1.00
Computer Science	UNISA – CS	2	3	2	2	5	1	0.65	0.86
Comp Sci & Inf Tech	Vista, Pretoria				1	5	3		0.67
Computer Science	Western Cape	1	3	2	1	4	1	0.67	0.83
Computer Science	Witwatersrand – CS	6	3	2	7	1	0	0.82	1.00
	Total	47	48	19	46	54	19		
	Average	2.74	2.82	1.09	2.83	2.83	1.11	0.85	0.82
Information Systems									
Information Systems	Cape Town – IS	1	2	5	2	4	5	0.38	0.55
Business Inf Sys	Durban-Westville - BIS					1	1		0.50
Business Inf Sys	Natal Durban – BIS	1	1	3	1	0	5	0.40	0.17
Information Systems	North – IS	1	1	1	1	1	1	0.80	0.67
Business Inf Sys	Pietermaritzburg – BIS	2	2	1	2	2	0	0.75	1.00
Informatics	Pretoria – Inf	2	4	5	2	9	5	0.55	0.69
Business Inf Sys	Rhodes – BIS	0	2	4	1	3	1	0.33	0.80
Information Systems	UNISA – IS	4	8	7	4	13	3	0.65	0.86
Information Systems	Witwatersrand – IS	1	4	3	1	5	2	0.63	0.75
	Total	12	24	28	15	38	23		
	Average	1.55	3.01	3.55	1.87	4.25	2.58	0.56	0.66
Technikons									
Computer Studies	ML Sultan				1	2	7		0.30
Business School	Northern Transvaal				0	0	2		0.00
Computer Data Proc	Orange Free State				0	4	8		0.33
Information Technology	Technikon SA				1	1	7		0.22
Computer Tech.	Vaal Triangle				0	5	3		0.63
School for IT	Witwatersrand					1	4		0.20
	Total				2.0	13.0	31.0		
	Average				0.40	2.17	5.17		0.21
External									
Comp Sci and Soc Sci	Malawi, Zomba				3	0	1		0.75
Computing	Namibia					2	1		0.67
Computer Science	NUST, Bulawayo				3				1.00
Computer Science	Zimbabwe, Harare				4	2	0		1.00
	Total				10.0	4.0	2.0		
	Average				3.33	1.33	0.67		0.85

Notes for Contributors

The prime purpose of the journal is to publish original research papers in the fields of Computer Science and Information Systems, as well as shorter technical research notes. However, non-refereed review and exploratory articles of interest to the journal's readers will be considered for publication under sections marked as Communications or Viewpoints. While English is the preferred language of the journal, papers in Afrikaans will also be accepted. Typed manuscripts for review should be submitted in triplicate to the editor.

Form of Manuscript

Manuscripts for review should be prepared according to the following guidelines.

- Use wide margins and $1\frac{1}{2}$ or double spacing.
- The first page should include:
 - title (as brief as possible);
 - author's initials and surname;
 - author's affiliation and address;
 - an abstract of less than 200 words;
 - an appropriate keyword list;
 - a list of relevant Computing Review Categories.
- Tables and figures should be numbered and titled.
- References should be listed at the end of the text in alphabetic order of the (first) author's surname, and should be cited in the text in square brackets [1–3]. References should take the form shown at the end of these notes.

Manuscripts accepted for publication should comply with the above guidelines (except for the spacing requirements), and may be provided in one of the following formats (listed in order of preference):

1. As (a) \LaTeX file(s), either on a diskette, or via e-mail/ftp – a \LaTeX style file is available from the production editor;
2. As an ASCII file accompanied by a hard-copy showing formatting intentions:
 - Tables and figures should be original line drawings/printouts, (not photocopies) on separate sheets of paper, clearly numbered on the back and ready for cutting and pasting. Figure titles should appear in the text where the figures are to be placed.
 - Mathematical and other symbols may be either handwritten or typed. Greek letters and unusual symbols should be identified in the margin, if they are not clear in the text.

Contact the production editor for markup instructions.

3. In exceptional cases camera-ready format may be accepted – a detailed page specification is available from the production editor;

Authors of accepted papers will be required to sign a copyright transfer form.

Charges

Charges per final page will be levied on papers accepted for publication. They will be scaled to reflect typesetting, reproduction and other costs. Currently, the minimum rate is R30-00 per final page for \LaTeX or camera-ready contributions that require no further attention. The maximum is R120-00 per page (charges include VAT).

These charges may be waived upon request of the author and at the discretion of the editor.

Proofs

Proofs of accepted papers in category 2 above may be sent to the author to ensure that typesetting is correct, and not for addition of new material or major amendments to the text. Corrected proofs should be returned to the production editor within three days.

Note that, in the case of camera-ready submissions, it is the author's responsibility to ensure that such submissions are error-free. Camera-ready submissions will only be accepted if they are in strict accordance with the detailed guidelines.

Letters and Communications

Letters to the editor are welcomed. They should be signed, and should be limited to less than about 500 words.

Announcements and communications of interest to the readership will be considered for publication in a separate section of the journal. Communications may also reflect minor research contributions. However, such communications will not be refereed and will not be deemed as fully-fledged publications for state subsidy purposes.

Book reviews

Contributions in this regard will be welcomed. Views and opinions expressed in such reviews should, however, be regarded as those of the reviewer alone.

Advertisement

Placement of advertisements at R1000-00 per full page per issue and R500-00 per half page per issue will be considered. These charges exclude specialized production costs which will be borne by the advertiser. Enquiries should be directed to the editor.

References

1. E Ashcroft and Z Manna. 'The translation of 'goto' programs to 'while' programs'. In *Proceedings of IFIP Congress 71*, pp. 250–255, Amsterdam, (1972). North-Holland.
2. C Bohm and G Jacopini. 'Flow diagrams, turing machines and languages with only two formation rules'. *Communications of the ACM*, 9:366–371, (1966).
3. S Ginsburg. *Mathematical theory of context free languages*. McGraw Hill, New York, 1966.

Contents

Editorial	1
---------------------	---

GUEST CONTRIBUTION

Information Technology and South Africa's Green Paper on Science and Technology E Blake	2
--	---

RESEARCH CONTRIBUTIONS

An Approach for The Standardisation of Policies for Selection of Computer Hardware and Software D Petkov	13
ATM Transmission Convergence Implementations: SONET/SDH vs Cell-Based N de Jager and J Roos	18
Efficient Shared Memory Multiprocessing and Object-Oriented Programming P Machanick	23
Reviewing IS Curricula: A Practical Approach L Froneman and JD Roode	31
The Evaluation of Business Process Reengineering Projects in South Africa L Whittaker	40

COMMUNICATIONS AND VIEWPOINTS

The Status of Computing Manpower and Training in Tertiary Education in Southern African Universities 1995 JM Bishop	A54
--	-----
