

**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*

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	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

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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.

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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

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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 lead 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

Reviewing IS Curricula: A Practical Approach

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Abstract

Many curriculum designs are based purely on what educators think it should be, reflecting their own experiences or idiosyncrasies, with little reference to the needs of the information systems field. A number of studies have been done to determine the skills needed by IS graduates, and several curricula have been put forward – most recently the IS'95 proposal. All of this presents a problem for IS Departments of how to incorporate these various inputs into their present curricula. In this paper we give an overview of a practical approach to undertake a formal curriculum revision.

Keywords: *IS Curriculum; IS Skills Requirements; IS Training and Development*

Computing Review Categories: *K.3.2*

1 Introduction

It has been noted by Jenkins [12] that many curriculum designs have been based purely on what educators think it should be. In this, educators would often reflect their own experiences of what should be done, or entertain a particular idiosyncrasy, with little reference to the views expressed by businessmen and knowledgeable people in the information systems field.

In order to correct this biased base of curriculum designs, a number of studies have been done to determine the skills needed by entry-level programmers, systems analysts and end-user support personnel. Further studies have also included the skills needed by IS managers, compared to the skills needed by programmers and analysts.

There exists a definite need for further research to be done in the field, especially for valid and reliable research to assist tertiary institutions in setting up their curricula in order to be beneficial to academics, IS professionals and businesses alike. This study intends to address this need.

An independent survey was undertaken during 1994 to determine the skills and competencies levels at which South African industry expects graduates of an Information Systems education programme at a tertiary institution to perform [7, 10]. This study was also intended to guide a comprehensive curriculum revision exercise which was planned at the University of Pretoria for 1995. The last major planning of the curriculum was undertaken during 1991, and it was felt that the time was ripe to reconsider some of our major assumptions and objectives. At the same time, during the International Conference on Information Systems in Vancouver in December, 1994, IS'95 [5] was announced and discussed. It was clear that any serious curriculum revision would have to take IS'95 into account.

To guide the curriculum revision process, we designed a framework and described a structured approach to undertake such an endeavour [9]. As part of applying this structured approach, it was necessary to do a detailed anal-

ysis of IS'95. An established curriculum analysis procedure [11] was employed and a hermeneutic approach to analyze IS'95 [8] was utilised.

The purpose of this paper is to give an overview of our approach to curriculum revision which is based on the above work. The approach, although well-founded in solid theoretical foundations, is decidedly practical, and aimed at showing how this could be applied by any tertiary institution. It should be noted, however, that such a curriculum revision process entails quite an inordinate amount of work. The results, we believe, are worth the effort.

2 Background

A part of the input to the present curriculum review process was an investigation to determine the skills and competencies employers require of IS graduates. These requirements could be used to evaluate present curricula in order to point out any deficiencies if they exist.

The various levels of ability required for both skills and competencies were taken from work done by Jenkins [12], and are defined as follows:

- Proficient: Performs task without supervision
- Knowledgeable: Has knowledge, but needs supervision
- Familiar: Understands the concept, but needs close supervision and more training.

A number of analysis methods were used to analyze the data, and the results were reported in [7] and [10]. A summary of the skills deemed important at each of the three levels for the different types of personnel is given in Table 1, obtained from the results of contingency analysis.

Internationally, the typical undergraduate IS curriculum demands four years of study. Judging from the list of skills deemed important for an IS graduate, four years of study would indeed seem unavoidable for South African tertiary institutions.

Table 1. Results of contingency analysis

	PROGRAMMERS	SYSTEM ANALYSTS	END-USER SUPPORT PERSONNEL
Competencies			
Business communication and interpersonal skills		●	●
Information systems planning		●	○
Management skills	○	○	
Peopleware			●
Systems approach		●	
Legal aspects of computing	○	○	○
Skills			
Application programming languages (COBOL, PASCAL,...)	●		○
System analysis and design		●	○
Problem solving	●	●	●
Data base concepts/Data structures	●	●	
Operating Systems		○	
Business knowledge and skills (Accounting, Marketing)			●
Documentation skills	●	●	
Fourth generation languages	●		
Mainframe experience		○	○
Packages (Spreadsheet, Wordprocessing, Graphics)		□	●
Telecommunication and networking	○	○	
System implementation		●	
CASE methodologies		○	○
Modelling (Math, Statistics)	○	○	○
Decision Support Systems/ Executive Information Systems			●
Expert Systems/Artificial intelligence	○	○	○
Writing skills		●	●
Presentation techniques		●	●
CASE tools		○	○

Legend: ● – proficient; □ – knowledgeable; ○ – familiar;

3 Comparison With Previous Research

Most of the studies undertaken to determine the training needs of IS personnel, were conducted in the USA, and only a fragment of this type of research was done in South Africa. The findings of some international studies will be presented first, as they have some generic implications for any curriculum design. After this, the South African situation will be reviewed.

International research

Jenkins [12] conducted a study in 1984 to determine the education requirements for entry level business systems analysts. Only the skill of drawing systems flow charts were found to be required at the proficient level. His study also disproved the assumption that programming is the only entry point to the systems analysis profession, with 26,7% of the respondents having had no previous job related programming experience. It is also interesting to note that the study identified two subjects requiring two or more courses, namely, Computer programming and English grammar.

Albin and Otto [1] identified skills that employers were

looking for when hiring new staff. Their conclusions stated that employers wanted CIS (Computer Information Systems) majors to be well-trained in COBOL and systems design, with good business communications skills developed through participative class and co-operative projects. Furthermore, employers wanted business majors to be exposed to micro computers and micro-based software packages, particularly spreadsheets.

Zawacki *et al.* [16] pointed out that there was a general shortage in the supply of systems analysts, systems programmers, network planners and software engineers. This has two implications. Firstly, the need of the right education and training for these types of personnel are accentuated. Secondly, the role IS curricula play in this shortage of qualified personnel needs to be investigated. Zawacki *et al.* investigated the latter with a three year study of over 500 business students, that brought to light some interesting facts. IS careers were generally chosen early on, often due to external pressure by parents and lecturers. Fifty percent of the participants made a commitment to an IS career during intermediate IS courses, whereas only 43% of participants in other intermediate courses committed them-

selves to a specific career. During the advanced IS courses, the percentage of participants that had committed themselves to IS careers had fallen to forty five. The reason for this was that the participants became disillusioned with IS as a career choice.

This disillusionment seems primarily to be the fault of the way IS curricula are set up with the introductory courses comprising technical topics and the advanced courses, the people-orientated topics. Introductory courses generally include programming and a general study of business information. This results in students choosing IS as a major without realizing the total package of skills needed to be successful in the IS profession. Zawacki *et al.* suggest that curricula should expose students to more entry-level courses on group dynamics, human behaviour, negotiation skills and conflict resolution, since the profession will continue to move towards end-user computing. This notion is supported by the IS'95 curriculum recommendation that programming should be taught in the third and fourth year of study instead of during the first two years, while more emphasis should be placed on IT and Society during the first years of study. This may also prevent students from choosing an IS career for the wrong reasons which causes a high turnover rate and low job satisfaction.

A survey done by Cheney, Hale & Kasper [3] compared data from 1978 and 1987 to examine the relative importance of the six skill requirements areas identified in the IS curriculum recommended by the ACM. Their general conclusions indicate that managerial and human factors skills have increased in importance, especially for project managers and systems analysts. They expect the need for increased knowledge in technical skill areas to decrease. This confirms an earlier study done by Cheney & Lyons [4] and is also supported by a more recent study done by Watson *et al.* [15].

On the other hand, the skills of Computer Simulation and Statistical Decision Theory are gaining importance across all job categories. Dramatic changes have occurred in the perceived value of Telecommunications Concepts, Computer Security Controls and Auditing, and Legal Aspects of Computing. Many of these skills present complete reversals in the 1978-1987 comparison, and are expected to be very valuable in future.

Their findings also show that Software Package Analysis, Legal Aspects of Computing, Computer Simulation and Statistical Decision Theory skills currently are and are expected to continue to be valuable to systems analysts. The same is true for programmers, with the exception of Statistical Decision Theory. Planning and Control of System Projects, Application Programming Languages, and Mainframe Hardware are perceived to be significantly less valuable now and in the future for systems analysts.

Systems Design Topics, Planning and Control of Systems Projects and Operating Systems are perceived to be less valuable to programmers, now and in the future.

The trend for systems analysts is toward increased knowledge of people and problem-solving skills, and away from developing application software. For programmers,

the emphasis is placed on networking, distributed processing systems, and utilization of DBMS.

A study of requisite skills for new MIS hires were also completed by Watson *et al.* [15]. According to the authors, their study reflects the need to train IS professionals differently for different positions. Results indicated that knowledge of applications programming languages, systems analysis and design, problem solving and related technical skills were considered to be important for an entry position as a programmer. The most important skills for systems analysts were systems analysis, while business communication and interpersonal skills and knowledge of the business were important for both systems analysts and end-user support personnel. Knowledge of spreadsheets, graphics, word processing and other PC packages was also considered important for end-user support personnel. Legal aspects of computing were ranked the lowest for all three job classifications. This is interesting as most other studies found that legal aspects of computing are increasingly becoming important [3].

Nelson *et al.* [13] conducted a survey to determine the perceived level of deficiency of the knowledge/skill areas as put forward by Zmud [17]. He defines deficiency as the difference between the usefulness of a knowledge or skill area (for successful job performance) and an individual's proficiency in that area – the larger the difference, the higher the deficiency.

The following recommendations were made by Nelson *et al.*:

- Improve the general IS knowledge of all employees;
- Improve the organizational knowledge of IS personnel;
- Improve the technical and IS product-related skills of end-users;
- Educate IS and end-user personnel to make each more sensitive to the other's problems;
- Conduct periodic needs assessments.

Our results indicate that legal aspects of computing are significantly more required at a familiar level by all three job categories. This supports the findings of Watson *et al.* [15] and contradicts the findings of Cheney, Hale and Kasper [3] that proposed that legal aspects of computing are gaining importance. The results of our study might have been influenced by the organizational maturity of IS departments or these skills might only be required of higher level positions in the IS departments.

South African based research

An evaluation of the skill requirements of entry-level graduates in the information systems industry in South Africa was recently done by Smith, Newton and Riley [14]. They found that there was a general agreement between academics and industry as to the skills required of graduates entering the IS industry. However, academics perceived a greater need for PC skills than industry, where a perceived need for more mainframe skills existed. This is in contrast to our findings and those of Cheney, Hale and Kasper [3]. A greater need for business skills were also perceived by academics, particularly in the areas of accounting and law,

while industry required considerably more inter-personal skills than what the authors think is currently being offered.

All of the studies reviewed in this section, except the study done by Smith, Newton and Riley [14], indicate that IS curricula are too technically oriented. Businessmen and IS managers are placing more emphasis on general and managerial skills, with communication skills cited by all studies to be very important.

4 Comparison Between an Informatics Curriculum and IS'95

The Department of Informatics describes informatics, as a field of study, as follows:

Informatics is an interdisciplinary field of study in which information, information systems and the integration thereof with the organization are studied in order to benefit the entire system (individual, organization and society).

The fundamental research question underlying all research in Informatics is seen as follows:

"How to reconcile the contribution to the attainment of the mission of the organization through the development, implementation and management of information systems and information technology, on the one hand, with the responsibility of ensuring the social acceptability of these systems on the other hand"

The Department of Informatics at the University of Pretoria believes that its educational responsibility lies therein to train students to be knowledgeable in systems and to have

the ability to solve problems concerning business information systems. The goal of the department is not to train programmers, but to train systems analysts and end-user support personnel.

Study in Informatics is introduced with systems concepts and problem solving in order to install a systems perspective in the student. Thereafter other aspects such as the analysis of an information system, the design, programming and implementation of the final solution fall into place.

The undergraduate program lasts over a period of three years. Nine courses are presented, three per year, with six optional additional lectures per year that cover topics not accommodated in the formal program. An additional one year honours program is presented as capstone for the undergraduate program. Including the honours program, the undergraduate program is more comparable to overseas undergraduate programs which generally comprise four years of study.

In Table 2 we compare aspects of the IS'95 curriculum with our present curriculum.

One aspect of the IS curriculum of the Department of Informatics that is not clearly stated in the IS'95 curriculum, is the holistic relationship between man, the organization and technology. This holistic relationship is accentuated throughout the IS curriculum. In particular, it is emphasized that the introduction of technology requires a process of change within the organization. This process of change can only be successful if the effect of this organizational change upon man is considered and successfully dealt with. Change in any one of the components in the triangular relationship, results in changes to the rest.

Table 2: Comparison between IS'95 and Informatics at UP

Characteristics of IS Graduates	
IS'95 IS graduates must ...	Informatics (UP)
COMMUNICATIONS <ul style="list-style-type: none"> Communicate using oral, written and multimedia techniques. 	This is covered across all three years of study and the additional enrichment lectures.
PROBLEM SOLVING <ul style="list-style-type: none"> Be able to choose from and apply different problem solving methodologies. Think creatively in solving problems. Be able to work on project teams and use group methods to define and solve problems. 	The topics of problem solving, creative thinking, lateral thinking and the soft systems methodology are covered in the specialist first year course. The use of these skills extends throughout the remaining program.
ORGANIZATION AND SYSTEMS THEORY <ul style="list-style-type: none"> Be grounded in the principles of systems theory. Have sufficient background to understand the functioning of organizations. Understand and be able to function in the multinational and global context. 	Organizational and systems theory are introduced in the second year of study, where a sound foundation is laid for further study. These areas of study are covered in depth in the fourth year of study.

Table 2: (continued)

IS'95 IS graduates must ...	Informatics (UP)
<p>INFORMATION TECHNOLOGY (DATABASE, MODELLING, IS DEVELOPMENT)</p> <ul style="list-style-type: none"> ● Function competently at an entry level position, being able to describe and develop Information Systems both personally and in groups. ● Understand modelling, measurement, and simulation approaches and methods. 	<p>These subjects are covered throughout the program, the capstone to this area of study being the third year project, which requires students to develop a system for a business that they themselves have to find, giving them practical experience.</p> <p>Modelling as such is not covered extensively, students are only familiar with the concept of modelling and are unfortunately not always able to use or design their own modelling approach.</p>
<p>INFORMATION TECHNOLOGY (COMPUTER HARDWARE, COMMUNICATIONS, OPERATING SYSTEMS)</p> <ul style="list-style-type: none"> ● Develop sufficient understanding of relevant software and hardware engineering concepts. ● Have the ability to apply and work readily with central, networked and telecommunicating distributed systems; and must integrate hardware, software and communicating systems into effective organizational solutions. ● Adjust rapidly to specific hardware, software and communications environments. 	<p>A shortcoming of the present course is the absence of quantitative analytic methods in the curriculum. Students are able to take a course in statistics, which is helpful in general, though it lacks specific reference to IS related problems.</p> <p>The rest of the study areas are covered in the first and third year of study. In general though, students lack practical experience.</p>
<p>QUALITY</p> <ul style="list-style-type: none"> ● Understand quality, planning, the continuous improvement process as it relates to the enterprise, and tools to facilitate this. ● Have a good understanding of error control, risk management, process measurement and auditing. ● Possess a tolerance for change and skills for managing the process of change. ● Think about education as being continuous. ● Understand principles of effectiveness, and their application in principle centred leadership, setting a high ethical standard. ● Be able to use project management tools in a project environment. ● Possess an awareness of management application techniques, professional and ethical concepts, legal issues, and strategic planning. ● Be able to provide essential support for the decision making process in organizations. ● Understand mission directed, principle centred mechanisms to facilitate aligning group as well as individual missions with organizational missions. 	<p>All the aspects of quality are addressed during the second year of study and specific topics are covered in more depth during the fourth year of study.</p>
<p>GROUPS</p> <ul style="list-style-type: none"> ● Interact with diverse user groups in team and project activities. ● Possess communication and facilitator skills within team meetings and other related activities. ● Understand the concept of empathetic listening, and utilize it proactively to solicit synergistic solutions in which all parties to an agreement benefit. ● Be able to communicate effectively with a changing work-force. 	<p>User groups and project activities are covered throughout the specialization courses, though more attention could be given to communication and facilitator skills.</p>

Table 2: (continued)

IS'95 IS graduates must ...	Informatics (UP)
<p>INDIVIDUAL CHARACTERISTICS</p> <ul style="list-style-type: none"> • Communicate effectively, continue to learn and update their skills, renew their principles, and be confident in their abilities as professionals. They must be sensitive to the expanding role IS plays in society and understand the evolving implications of their professional, ethical, legal and social responsibilities. • Cultivate creativity and develop a tolerance and respect for this characteristic in others. • Be able to enter and continue successfully through a four year program, and perhaps continue into a graduate course of study. • Understand personal goal setting, must understand and demonstrate the concept of making a decision, committing to perform work, and rigorously completing agreements. • Be committed to life-long learning, and must have the skill and desire of knowing how to learn. 	<p>These individual characteristics are, in general, personal traits which can, at most, be developed during a properly constructed curriculum. They cannot, however, be taught. The only remedy is to support the recommendations made by Zawacki <i>et al.</i> (1988) on course structuring in order to facilitate a natural selection process.</p>

5 A Curriculum Revision Project

In this section we describe a formal curriculum revision project in progress at the University of Pretoria, based on a generic framework for the improvement of IS Curricula [9] and a formal analysis of IS'95 [8].

A generic framework for the improvement of IS Curricula

The implementation of curriculum proposals presents academic institutions with a difficult problem. For various reasons it might be impossible to implement the curriculum in its entire proposed form. Even if one were to select from the proposed courses and follow the course descriptions, the result would not necessarily be an improved curriculum. Without appropriating and internalizing the curriculum proposals, an institution cannot hope to be successful in redesigning its curriculum. One cannot merely select from the proposed courses in IS'95 and adopt the course descriptions – this will not constitute an improved curriculum, although it might be based on the serious groundwork done by the joint task force.

The above question was addressed in [9] where a framework and a structured approach were described which can be used by any institution planning to redesign its curricula. The structured approach ensures an appropriation process.

At the heart of the structured approach is the double loop learning process shown in Figure 1. The framework shows that a curriculum is usually based on a formal or informal conceptualization of the total program, or components of it. In formalising such conceptualizations, an institution will wittingly or unwittingly make certain assumptions and set certain norms for its intended program, reflecting local beliefs and making provision for local conditions.

The assumptions and norms play a determining role in that the program requirements, curriculum, course requirements and teaching methods are logically derived from them. This does not mean that the program and curriculum are fixed once the assumptions and norms are laid down – they can indeed be incrementally changed as indicated by the single loop learning feedback.

In Figure 1 the blocks represent information of a particular kind, eg., the curriculum description or external assessment results. The process of acquiring or changing the information is indicated by the flow lines. These processes are described in our structured approach below in terms of discrete Phases.

The most important part of the model is the learning components constituting single and double loop learning, based on the results of external assessment and alumni/employer survey information. Also shown is the important (single loop) learning based on the results of student performance evaluation. This is not seen as part of the curriculum improvement process discussed below.

The assumption is that the institution already has an IS curriculum in place, but desires to upgrade this. How should the institution decide what, if any, to incorporate of various external proposals or recommendations in its present curriculum? It is proposed that a structured approach to curriculum improvement should be followed, and the framework in Figure 1 is used to describe the process. It is important to realise that the phases below are not necessarily executed sequentially. Phase C could be executed in parallel with A and B, and A need not be completed before B could start.

Phase A: Determine the assumptions and norms implicitly or explicitly used in designing the present program. Some assumptions and norms would have been made clearly and explicitly. Yet, it might require a major effort to find and identify them. Other assumptions

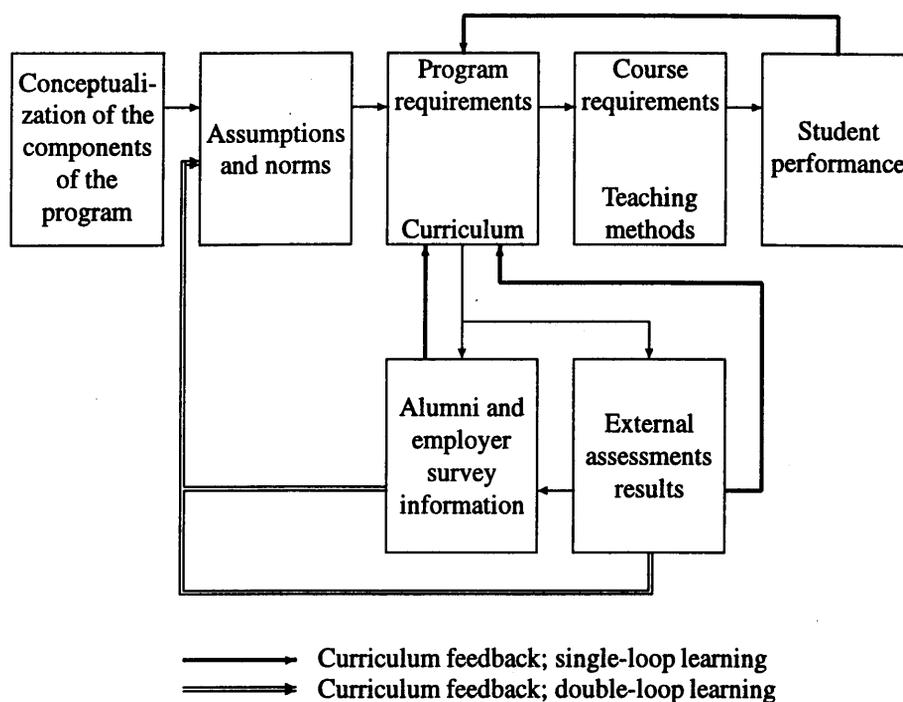


Figure 1. A Framework for Curriculum Improvement

might have to be uncovered through a backtracking process, starting with current components. This could bring to light hidden assumptions which were never made explicit, and “unwarranted” components which just “happen to be” in the program without ever being formally planned to be there (eg, because the ability to teach that component was readily available). Before reconsidering these assumptions, it is necessary to ascertain on what grounds they were based. Thus, myths, being part of the folklore of the institution or the faculty, could play a major role.

Phase B: Ascertain how assumptions and norms influenced the present program.

Knowing what went into the curriculum building process does not mean that one knows how this led to the present program. It is also not necessary to reconstruct the process: the objective should rather be to attempt to understand in what way the assumptions and norms have had an impact on the current components. A curriculum, built and shaped over years, is a complex web of interrelated elements, and careless removal of some of them might bring the whole structure down.

Phase C: Conduct alumni and employer survey, and/or external assessments.

External assessment could be done:

- By peer evaluation as part of an accreditation scheme
- By senior staff from businesses with which the institution has formed a partnership or alliance, against internal or external standards
- Through self-evaluation against external standards, such as IS'95.

Alumni and employer surveys are important ways of obtaining unbiased information about the competen-

cies and skills expected of graduates. Several such surveys, reported in the literature, can be used as models.

In interpreting the results of such surveys, one should keep in mind that employers have a shorter time frame in mind than academic institutions. An institution should also prepare its graduates for technological and other changes it anticipates, even if they are barely discernible. Some of this will never surface in a survey as skills a graduate should possess. An institution therefore has to balance these conflicting requirements in constructing its curriculum.

Phase D: Rethink the current assumptions and norms.

This phase could easily be a quick exercise of “making sure that we are still on track”, serving little purpose. Having gone through phases A to C, though, an institution could get down to the essence of improving its curriculum, and proceed as follows (not necessarily sequentially):

- Decide upon an external standard(s), such as IS'95, against which the current program will be compared (if this had not already been decided during external assessment)
- Determine the assumptions and norms which form the basis of external proposal(s) but not of the current curriculum
- Identify the “reasons” why these assumptions were used or not used and decide upon their validity.

Phase E: Identify the assumptions and norms which should be reconsidered.

The results of phase D are combined with academic inputs and are not simply mechanically processed to provide a result. The institution has to decide on the

elements which will effect a change of the program, course contents, and, eventually, teaching methods.

Phase F: Constitute the new program and course contents.

In this phase, the institution formally establishes its new program and gives details of course contents and teaching methods, using revised or new assumptions and norms. The level of detail achieved in IS'95 should be the ideal, providing students (and faculty) with clear road maps or study guides. Standards for this might differ considerably, and an institution should not adopt the IS'95 format simply because it looks impressive on paper. If this differs considerably from local standards, it could prevent the internalization process and hinder, instead of support, the acceptance of the new curriculum.

A formal analysis of IS'95

During Phases C and D it is necessary to compare the current program with an external international standard such as IS'95, and to rethink the current assumptions and norms in the light of IS'95. For these purposes we had to undertake a formal analysis of IS'95. The concept of formal curriculum analysis is not a familiar one for IS professionals. During 1979 Gibboney [11] developed an approach to curriculum analysis which was quite unique in terms of its departure from the traditional ways of doing curriculum analysis. He suggested that a curriculum could be analyzed using four philosophical categories: its view of reality (metaphysics), its view of knowledge (epistemology), its underlying values, and its internal logic.

Gibboney's idea has gone through several stages of development and informal testing, and was published as TIE, *Toward Intellectual Excellence: Some Things to Look for in Classrooms and Schools* [11]. Ariav [2] analyzed 45 other schemes for doing curriculum analysis, and, in order to compare the different schemes, defined an "ideal" scheme. In this ideal scheme for doing curriculum analysis, Ariav defined fourteen characteristics which should ideally be incorporated in any analysis scheme. She then compared the different schemes by examining their closeness to the ideal scheme. Only eight schemes fulfilled at least eight of the desirable characteristics of the ideal scheme. Only five schemes fulfilled at least nine of the ideal's characteristics, and only one – TIE – was shown to fulfil eleven of the fourteen characteristics, making it superior to the other schemes and closest to the ideal scheme. These credentials of TIE convinced us to use it in our analysis of IS'95 which has been reported elsewhere [8]. The analysis is not discussed again – only the salient results are given below.

Our analysis led us to conclude that the very explicit objectives of IS'95 are detailed but largely rigid. This has the effect that the subject matter of IS'95 are also very rigid. If then, in our study of our own curriculum, we come to the conclusion that a larger measure of flexibility is needed than present in IS'95, we need to be careful in simply taking over the objectives or subject matter of IS'95.

First of all, one can select those objectives from IS'95

which through the use of our structured approach and analysis, prove to be relevant to one's current situation. These objectives could then be refined to incorporate the assumption and norms of the institution using them. For instance, one's objective concerning problem solving might be quite different from the objective(s) of IS'95 in this regard, and might reflect more of Denning's [6] vision of problem solvers as "... expert partners with clients in other domains that use computing ...". One could then broaden the learning units to include domains other than only the domain of computing.

Our understanding of IS'95 enabled us to refine certain objectives, in that we were able to redirect the focus of those objectives to be in line with our approach. If we did not possess this understanding of a document such as IS'95, all we would have been able to do, would have been to adopt the objectives, unchanged. These are generic objectives, and would not have facilitated the achievement of our stated objectives for the curriculum as a whole. Furthermore, without the results of the other phases of our structured approach, that enlightened us to the requirements of potential employers and alumni and the influence of our initial assumptions and norms (implicit and explicit) on our present curriculum, we would not have been able to assess which of the objectives of IS'95 are relevant to our particular situation. This implies that we would not have been able to select the objectives relevant to the needs of our local curriculum, and any selection made would then simply have reflected the idiosyncrasies of the curricularist.

6 Conclusions

Final conclusions concerning the success of our approach to curriculum revision will obviously only be possible upon completion of the project. At this stage it is useful to summarize the main components of the approach and to point out the advantages of following a formal structured approach.

We mentioned that a need exists for formal research in the area of curriculum requirements, and how to satisfy these. Our empirical study addressed this need in a South African context and, combined with the other available research results, form an important input to the process of curriculum redesign.

It is not enough simply to have such input without understanding how to use this to undertake curriculum redesign. Too often this would result in a simplistic cut and paste approach where new modules or components are spliced into an existing curriculum. The result, we have said before, need not be any improvement – indeed, it would probably dilute any educational value that such a program had. The solution, we believe, lies in following a formal, structured approach employing the basic idea of double-loop learning. To this end, we proposed and described a generic framework for the improvement of IS curricula, including a structured approach to apply this framework.

As part of the structured approach it is necessary to an-

alyze an external standard or curriculum proposal such as IS'95. Such analysis (of e.g. IS'95) is aimed at revealing its hidden or implicit underlying paradigm and educational value. We indicated how such an intensive analysis could be undertaken and discussed the use of the results of a formal analysis of IS '95. Without such a formal approach, an appropriation of something as complex as IS'95 is not possible, and one would revert to superficial redressing of an existing curriculum.

To prevent a curriculum from simply being a reflection of educators' own experiences or preferences, entertaining their particular idiosyncrasies, we propose a formal approach to reviewing IS curricula, which we described in this paper. Although it certainly entails a lot of work, the payoff would be worth the effort – an improved curriculum which is appropriate for the institution.

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Received: 7/95, Accepted: 3/96, Final copy: 4/96.

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