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United Nations
Educational,
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Organization

**Use of Information and Communication
Technologies in Science & Engineering
The Case of SADC Universities**



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TABLE OF CONTENTS

BOTSWANA		Page
1	Scope of the Paper	1
	1.1 Introduction	1
2	National ICT Policy: Current Status	3
	2.1 Infrastructure	6
3	Status of ICT in Institutions of Higher Education In Botswana	6
	3.1 ICT as a subject and a tool	6
	3.2 University of Botswana	7
	3.2.1 ICT as a tool	7
	3.3 ICT in Research with respect to Botswana Technology Centre	8
	3.3.1 Kitsong Centres	8
	3.3.2 Discovery Centre	9
	3.3.3 Multimedia Telemedicine Centre	9
	3.3.4 V-SAT Technology	9
4	General Conclusions and Recommendations	9
5	References	11

MALAWI

1	Introduction	14
2	Higher education in Malawi	14
	2.1 Universities	14
	2.2 Other Tertiary Institutions:	15
	2.3 Educational Challenges of University of Malawi	15
3	ICT Situation in Malawi	16

TABLE OF CONTENTS

MALAWI (CONTINUED)		Page
3.1	ICT National Policy	16
3.2	ICT in Higher EducaTion	18
3.2.1	<i>ICT as a Tool for Higher Education</i>	18
3.2.2	<i>Higher Education as a Tool for ICT</i>	19
3.3	ICT in Science and Engineering	19
4	Challenges	20
5	Concluding Remarks	21
6	References	21

MOZAMBIQUE

I.	Introduction	23
II.	Current Status of ICT Policy	23
III.	The Incorporation of ICT	25
IV.	ICT in Education	26
	1. ICT in Higher Education	26
	2. ICT in General education	28
IV.	Conclusion	29
V	References	30

TABLE OF CONTENTS

ZAMBIA		Page
1	Introduction	33
2	Status of National ICT Policy	34
	2.1 Policy Goal	34
	2.2 Commitments	34
	2.3 Objectives	34
	2.4 Strategies	35
3	ICT in Science and Engineering	35
	3.1 Incorporation of ICT in the Science and Engineering policy of the Institution	36
	3.2 Use of ICT in the classroom	36
	3.2.1 Science	36
	3.2.2 Engineering	36
	3.3 Use of ICT to Popularise Science and Engineering	37
	3.3.1 Science	37
	3.3.2 Engineering	37
4	Challenges	38
5	Suggestions	40
6	References	40
ZIMBABWE		
1	Current Status of the National ICT Policy	42
	1.1 Setting up a Policy implementation team	42
	1.2 E-readiness Survey	42
	1.3 Awareness Period	42
	1.4 ICT Policy draft	42
	1.5 ICT Policy adoption	43
	1.6 Impact on the University of Zimbabwe	43
2	Incorporating ICT in Science and Engineering in the national ICT policy	43

3.1	University strategic plan	44
3.2	University ICT policy	44
3.3	University ICT Strategic plan	45
3.4	Teaching/Courses	45
3.5	Library	45
	3.5.1 Provision of E-resources	45
	3.5.2 Digitizing of Examination Resources	45
3.6	Research	45
4	Use of ICT in classroom	46
4.1	Campus wide and faculty laboratories	46
4.2	E-learning project	46
4.3	Examinations on line	47
4.4	Open Distance Electronic Learning ...	48
5	Use of ICT to popularize Science and Engineering	48
5.1	The Groombridge Primary School Project	48
5.2	Project by students	48
5.3	Student associations	49
5.4	The Faculty of Engineering Student Projects Show	49
6	ICT as a subject in the institution	49
6.1	Computer Science Department	49
	6.1.1 Higher degree programmes	49
6.2	ICT related departments	50
6.3	General ICT courses	50
6.4	ICT for life long training	51
	6.4.1 Cisco Regional Academy	51
	6.4.2 Anstead School of Technology	51
7	Conclusion	52
8	Appendix	52



**USE OF ICT IN INSTITUTIONS OF HIGHER
EDUCATION AND RESEARCH AND
DEVELOPMENT IN
BOTSWANA**

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1.0 Scope of the Paper

This paper examines the status of Information and Communication Technology (ICT) in Botswana with respect to its usage for educational purposes and for research. The paper is structured in three parts. Firstly, it provides a brief overview of the status of the National ICT Policy in Botswana. Secondly, it reviews the usage of ICT in higher education in Botswana focusing on the University of Botswana, and in research with respect to Botswana Technology Centre. Thirdly, recommendations and conclusions are made.

1.1 Introduction

Information and Communication Technology (ICT) has emerged worldwide as a technology that augments the process of information exchange and reduces transaction costs. It is instrumental in increasing productivity, efficiency, competitiveness and growth in all spheres of human activity. The potential benefits of the technology can, however, only be realised if the technology can diffuse across all sectors of society. Unfortunately, societies are trapped in the "digital divide" where the majority of the people, especially those in the rural areas, do not have access to information or communication links. With the emergence of globalisation, it has been argued that the ability to harness the technology for both the urban and the rural populace will improve the capability of most developing countries to participate in ICT.

The nation of Botswana, especially the rural community, is no exception when it comes to the "digital divide". Although Botswana has experienced a rapid increase in the use of ICT, the pattern of diffusion of these technologies has been extremely uneven in the country, with the benefits accruing from the technologies being felt only in the modern urban based sectors of the economy (Duncombe 1999:62).

Botswana has, as one of its priorities, to ensure that every citizen (Motswana), despite their geographical location (ie. both rural and urban dwellers) be provided with education and access to information that they need for self-empowerment (National Vision 2016). In order to transfer to a knowledge based society, the country must invest in education and human resource development. The importance of a workforce base that can support deployment and exploitation of ICT services and technologies and an information economy cannot be over-emphasised. It was therefore found critical to invest in all levels of formal education from the lowest (primary) to the highest (tertiary). This required working with the private sector to create possible training opportunities, as well as promotion of a national environment that is conducive to job creation in the ICT sector. ICTs can also facilitate efforts to widen access to education and training at all levels. Botswana recognises the development and role of ICTs as having the positive potential to impact across society and organisations, and will contribute greatly to the nation's development. There is also an increasing recognition that development should have people's growth as its central pillar, along with economic growth. To this effect, governments around the world are focusing on strategies to increase access to and improve the quality of education. ICT is enhanced by a policy that ensures that people are capable of using it to source and assimilate information and transform it into useful knowledge. On the other hand, ICT for development depends upon economic, social, cultural and technological factors in order to create a platform for education and development. In this context, the government of Botswana faces many challenges in its effort to cater for all its learners. The challenges are: a population, though small, which is sparsely distributed, inadequate infrastructure for linking up all sectors, inadequate financial resources, high cost of telephone bills, most villages are not electrified, there is a small number of teachers, especially in ICT, insufficient and poor quality of learning resources. Botswana has to take into account all these factors when creating an environment and conditions that will encourage and provide opportunities for using ICT to support the development process in the country.

It is against this background that the government of Botswana undertook the step of developing a comprehensive national draft ICT policy, which would cut across all sectors of society and overcome the digital divide.

2.0 National ICT Policy: Current Status

Botswana is currently developing a national ICT Policy locally known as "Maitlamo". This Draft National Policy provides a roadmap to drive social, economic, cultural and political transformation through the effective use of ICT. It is driven by the fact that ICT is a significant contributor to preparedness for global competition and a driver for development including education. The country also recognises the huge potential of ICT applications as a key factor in fostering economic development. ICT technologies in this case include radio, television, telephone, computers, internet and e-mail. The government of Botswana through the Ministry of Communications, Science and Technology (MCST) has led the country in spearheading this effort as a commitment to ensure that Botswana enters the information age on an equal footing with other nations.

The development of this policy involved a whole range of stakeholders, such as the Department of Information and Technology, which is responsible for deployment of ICT across the Civil Society sector; Botswana Telecommunications Corporation (telecommunications services provider); Botswana Telecommunications Authority whose responsibilities include licensing telecommunications and broadcasting operators, Botswana Power Corporation which has the responsibility to provide electric power; University of Botswana responsible for education and training of the workforce and Botswana Technology Centre undertakes the deployment of Science and Technology capital. Private ICT-based institutions also play their role alongside BOTEC. The Policy is guided and supported by an Act of Parliament, wholly supported by government budgets and implemented through national programmes and projects. There was an initial considerable nationwide effort undertaken to conduct e-readiness surveys which covered the economic, social and political sectors. This has also helped to get buy-in from all the key stakeholders including politicians.

The Maitlamo Draft Policy was developed over a period of six months (June - December 2004) and is now in its final phase before approval by Parliament.

The overall objective of the ICT Policy is:

- Creation of an enabling environment for the growth of an ICT industry in the country
- Provision of universal service and access to information and communication facilities in the country; and
- Making Botswana a Regional ICT Hub so as to make the country's ICT sector globally competitive.

To achieve the objectives above, Government has embarked on some initiatives and programmes which include:-

- A significant investment was recently made in upgrading Botswana's communications network to facilitate new technologies through establishment of the Ministry of Communications, Science and Technology (MCST) which is specifically dedicated to ICT.
- Introduction of e-government initiatives which will bring services closer to the people and hopefully act as a catalyst for the public as well as the private sector to embrace ICT.
- Cognisant of the need for a strong research science and technology (RST) capability to create a knowledge society, the Government is in the process of restructuring existing RST institutions to better leverage scarce expertise and improve coordination of research efforts.

- Efforts are being made to reduce communications costs in Botswana, mainly through further liberalisation of the telecommunications industry.
- Most government tertiary learning institutions in Botswana are equipped with internet -Enabled computers.
- Government has committed USD 60 million to rehabilitate and fortify the national telecommunications network. In addition an amount of USD 60 million will be used to provide high capacity international connectivity through undersea cables off the east and west coast of Africa.
- The rural telecommunications initiatives brought modern telecommunications, including internet access capability to the villages.
- An optical fibre link has been introduced between the southern and eastern corridors of the country between Gaborone and Francistown. Work is also ongoing to ensure completion of fibre optic 'ring' around the country which will enhance the quality of international Connectivity. This work is scheduled for completion by 2006 (*source: WITFOR 2005*).

These efforts by the government of Botswana are commendable and also show there is commitment to the implementation of the Maitlamo National ICT Policy. It is however important to ensure that this momentum is not lost. This can be achieved if the private sector, NGOs, Parastatals etc. play their role in development.

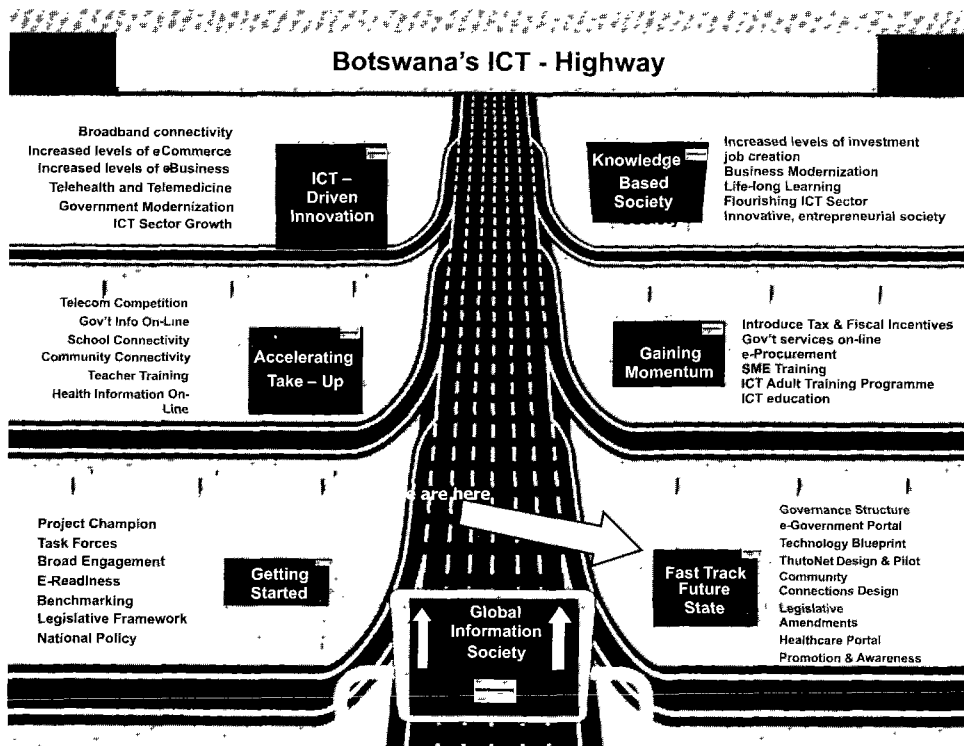
The Maitlamo Policy has a Master Plan which was designed in December 2004 and was to be implemented over 12 months (beginning January 2005). The purpose of the Master Plan was to provide an overview for actions which were to be implemented in the first year of the Policy. It will also help to monitor progress and ensure that momentum is maintained.

The key programme areas for implementation include the following and are also demonstrated by fig. 1 below:-

- Governance and ICT Adoption
- Connecting Communities
- Government Online
- Thutonet (e-learning)
- E-health Botswana
- ICT Economic Diversification
- Connecting Botswana
- Connectivity Laws and Policies

The successful implementation of the Master Plan requires all the different stakeholders (government, politicians, private sector, parastatals, Non Government Organisations, Community Based Organisations, etc) to demonstrate their commitment by putting in place implementable ICT institutional policies, as well as ensuring that ICT plays a specific role in their strategic plans.

Fig. 1 Diagram showing phased progress



Source: Maitlamo Draft Policy 2005

2.1 Infrastructure

ICT applications would be impossible without a proper and appropriate telecommunications network. The following provides key statistical information showing the infrastructural accessibility status in Botswana:-

- 8% (132,000) of the population have land line telephones (March 2004);
- 31% (556,000) of the population uses mobile phones (March 2004);
- 2% of the population is considered regular internet users (2002);
- 380,000 radios in Botswana (2002);
- 34,000 computers (2002/04);
- 124,631 power connections (May 2004);
- Approximately 1,920 IP Hosts

3.0 Status of ICT in Institutions of Higher Education in Botswana

Education in Botswana from primary to university levels has been the sole responsibility of the government through the Ministry of Education. The Ministry provides quality education and training to learners of all school-going age groups, and creates opportunities to enable individuals to realise their full potential. The overall objective is to contribute to the national socio-economic and technological advancement of Botswana.

Vision 2016, a national manifesto for the people of Botswana, has as one of its key strategies on education "Botswana will be an educated and informed nation". This means that the government has to ensure delivery of quality education and that it is accessed by eligible Botswana anywhere in the country. In addition to the intentions of the national Vision 2016, Botswana education system has experienced continual pressure from global changes, the national context, societal expectations and demands. However these changes were also positive in that they brought about development. Examples of these changes include moving from the traditional system of delivering teaching under a tree to a classroom set up. The country has also witnessed a significant improvement in the level and the quality of qualifications.

In response to these challenges the Botswana Tertiary Council has developed a Draft Education Policy (2005). The purpose of the draft policy is:-

- Be cognisant of global trends and pressures that are impacting on tertiary education in Botswana as well as being responsive to specific societal challenges and needs.
- Clarify the goals for tertiary education for the next twenty years.
- Stipulate how the tertiary education system can best be developed, coordinated, resourced and regulated.

The government of Botswana faces a challenge in providing higher learning Institutions and training centres with access to ICT. This is due to the fact that a large percentage of the population lives in rural areas with inadequate supporting infrastructure, lack of IT skilled individuals within the country, and broadband internet access is very limited. PC penetration is very low in schools and homes across the country, especially in remote areas where access to electricity compounds the problem.

Higher learning institutions in this case referred to are:-

- Secondary schools
- Teacher training Colleges
- Vocational and Technical Training
- Colleges of Education
- Nursing Colleges
- College of Agriculture
- University of Botswana

It should also be noted that higher learning institutions are fed by primary schools whose quality of education forms the basis for the quality of higher learning. Therefore the provision of ICT and science and technology should start in the primary school. Recently, the government announced its plan of rolling out a project to give primary schools refurbished, used equipment from the government and the private sector. Further to this, an e-Learning programme is also being

formulated. This is a commendable initiative as it would help to sow the seed of science and technology in children at a tender age, and this would also eradicate the issue of techno-phobia at higher education and in the working world.

According to the Educational Statistics (2003), there were 279 secondary schools operating at the beginning of 2003. Of these schools, 23 are government owned which enrolled 30,035; 210 are government aided enrolling 118,681 and 46 are privately owned enrolling 5.1% of the total secondary school enrollment. These are then the products that are either enrolled at the university or other tertiary institutions. The role of the tertiary level is to provide high level manpower and research support needed for economic development. The Ministry of Education has a new ICT Curriculum with computer literacy as the foundation, and an elective computer studies component in the senior grades. The development of an ICT curriculum targets teachers at training levels with computer skills. Currently, the number of teachers training in computer skills is very low (1,798 out of 10000 teachers) in the secondary schools. The Human Resource Development Plan 2002 records that the number of students at home and abroad was 27,491 and of this number approximately 8,570 were enrolled in universities outside Botswana. Of these more than 50% were enrolled in science and technology courses.

3.1 ICT as a subject and a tool

ICT has proved to be invaluable as an efficient tool for dissemination of educational material across nations and to help handle administrative activities electronically. While ICT tools are inadequate in higher institutions, it is clear that these are not utilised to the optimum level. Some teachers and students are still holding on to the traditional methods and do not want to embrace this development. In some cases where institutes have ICT policies it is also not mandatory to use them. Furthermore, some students do not seem to see value in these infrastructures, and they have gone to the extent of vandalising them. It is further noted that some untrained teachers resent the technologies because of techno-phobia. These attitudes require aggressive training of teachers and students so that they can see the benefit that is intended.

Access to computers for learners in some schools is provided with the Computer Awareness subject (universal) and Business studies subject (secondary level). At the colleges and vocational schools students have access to e-mail, and can type their documents on a computer. File downloading is not allowed (for fear of virus/damage and poor connectivity) and in some instances computer labs are reserved for IT classes and use is restricted to a short time for walk-in students and teachers. Subjects generally taught include Mathematics; Integrated Science; Chemistry; Biology; Physics; Computers skills (elective); Design and Technology (elective) and Art (elective).

In addition, ICT is a foundational component that cuts across all programmes at tertiary level (Teacher Training Colleges, Vocational and Technical Training, Colleges of Education, College of Agriculture, etc). While the ratio of computer to student has been approximately 1:40 the effect of using ICT as a classroom tool is remarkable. Students have access to Internet, use email, as well as various applications such as Excel and PowerPoint, to do their assignments. All the graduates are computer literate by the time they graduate. It should be appreciated however that ICT is used to complement the efforts of humans, and should not be perceived as replacing face to face (interaction) learning and teaching.

The Botswana College of Distance and Open Learning (BOCODOL) currently offers limited secondary school courses, and vocational and pre-tertiary courses in technology related subjects. Five regional offices located in Gaborone, Francistown, Maun, Kang and Palapye form the network hub of the college. This initiative has been able to reach out to even the most remote places. However, it would be much easier if those areas had access to ICT.

2 University of Botswana

The University of Botswana, established in 1982, is the highest seat of learning in the country. A strategic objective of the University is to increase the number of full-time graduate students. The University has been able to deliver its objectives through the Faculty of Engineering and Technology; Faculty of Humanities; Faculty of Science, Medical Education and Faculty of Social Sciences. Through research and higher learning, graduate students will help to achieve the educated and informed nation of Vision 2016.

About 339 of 1384 students at the University of Botswana are enrolled in science related courses. In 2001, a total number of 186 students were enrolled in a Diploma of Computer Science and 153 in the Computer Science BSc programme. Approximately 25% of graduates have some form of IT training according to the Education Statistics Report, 2001. These numbers do not include tertiary education from outside Botswana.

The University offers an introductory course for all first year students which provides the basics for IT applications. There are major courses provided in Masters Degree programmes on IT, such as:- Information Technology, Business Information Systems, Computer Information Systems, Information Management.

Other IT courses offered at post graduate level include:- Principles of IT (Computer Hardware and Software, Telecommunications and Networks, Database Management Systems and Electronic Commerce, Programming, Web-site Development, Accounting Information Systems, Data Organisation Methods, Information Systems Security, Project Management Information Systems, Strategic Information Systems, Systems Analysis & Design, Information Systems Auditing)

ICT as a subject also is offered within General Education Courses (GEC1&2). This program is semesterised and it allows students who are not doing IT as a major course to do IT related courses according to their choice.

3.2.1 ICT as a tool

The University of Botswana has an institutional policy which should guide and provide direction for the use of ICT. This policy however does not seem to be firm in its attempt to ensure its implementation. As a result of this flexibility most lecturers still deliver their educational material and teach in the traditional way. Furthermore, the information system is not coordinated and as such some lecturers use programs which are not Microsoft based.

The Library is fully automated and therefore books, journals, articles etc. can be searched and borrowed by just pressing a button.

The Integrated Teaching System enables on-line registration of students, publishing of marks and access to examination timetables.

Other modes of delivery include facilities like WebCT, Sabinet, ISI Web of knowledge, EbscoHost, Networked CD-ROMs; Ms Office, AutoCAD and Turbo Pascal are installed on some computers.

In its effort to increase access, equity and participation in higher education by exploring the potential of ICT to deliver teaching and learning in new and effective ways, the University has an e-Learning programme including part time, distance learning and mature entry programmes.

There are some initiatives to ensure that the girl child is encouraged to partake in science courses. The University has a project under IDA where the students visit other schools and deliver talks to encourage the girls. However, at the university, gender issues on choice of subjects seem not to prevail. It has been observed that the female students are committed to their studies, and their performance has been more or equally as good as their male counterparts. It may be necessary to

conduct a study to establish the perception of disparity in participation of girls in science related subject and to understand the dynamics pertaining to this issue.

3.3 ICT in Research with respect to Botswana Technology Centre

The government through "Maitlamo" National ICT Draft Policy expects parastatal organisations and government departments to demonstrate their commitment in deployment of ICT projects and programmes to popularise science and engineering, or as development initiatives. According to Annan (2002), ICT development projects related to rural development can be categorised into three: decision support to public administrators, improving services to citizens and empowering citizens to access information and knowledge. The National Development Plan 9 (NDP 9) also expresses the need for ICTs to penetrate rural areas in particular, in order to accelerate development to achieve rapid integration of the country with the global economy (NDP 9:148).

Even though Botswana has a number of Research and Development Institutions the main responsibility for science and engineering research is tasked to Botswana Technology Centre (BOTEK). The Centre was established in 1979 and funded by government since 1982. BOTEK falls under the Ministry of Communications Science and Technology. Its operations are:-

- Renewable resources
- Sustainable Architecture
- Water technologies
- Environmental Management
- ICT for Development
- Science and Technology Promotion
- Technology Transfer
- Technology Solutions for Business Industrial Development

To deliver on the mandate, BOTEK has embarked on a number of projects, including:-

3.1.1 Kitsong Centres

In partnership with the government to close the digital divide BOTEK embarked on a project called computer communication system that would enable people living in rural areas to have access to an integrated e-mail and on-line information, (with emphasis on the distribution of locally generated information) for the various aspects of the development of the rural economy such as health, education and business. It also provides downloadable application forms for everything from drivers' licences to bank loans. The project is being piloted in the three villages of Letlhakeng in Kweneng West District, Hukuntsi in the Kgalagadi District and Gumare in North West District.

3.3.2 Discovery Centre

The Discovery Centre is an initiative by BOTEK. Its purpose is to try to alleviate the perceived apathy and resentment towards Science, Engineering and Technology (SET) which derives from the traditional stigma that SET is difficult to understand and thus not worthwhile to pursue. The Discovery Centre seeks to demystify this by simplifying SET concepts, and by combining the learning experience with fun.

The centre showcases scientific, engineering and technological concepts through working models, exhibits, simulations, lectures and talks. Exhibits may be static, dynamic or interactive. The Discovery Centre offers a rare and unique opportunity to explore SET concepts, which are normally not offered, by training institutions, and bridge shortfalls in such establishments. It is hoped that such an initiative will contribute and increase interest in science, engineering and technology.

3.3.3. Multimedia Telemedicine Centre

The project is a feasibility study for establishing a 24 hour multimedia Telemedicine Centre, which will enable doctors to remotely diagnose and prescribe treatment for patients anywhere in the country. The Centre will be linked to health facilities and medical rescue facilities through a hi-tech video conferencing system.

In this way, high-level instant treatment can be remotely provided to all parts of the country thereby narrowing the gap between health facilities in rural/remote areas and those in urban areas. Most importantly, it would save many lives; by helping to maximise the use of quality expertise available both locally and internationally. The project is prompted by the drastic shortage of doctors in our hospitals and clinics.

BOTEC in consultation with health and medical team has completed the study in March 2005.

3.3.4 V-SAT Technology

Botswana Telecommunications Corporation (BTC) launched Very Small Aperture Terminal (V-SAT) technology which it is hoped will play a role in bringing services to remote areas through the use of satellite overcoming limitations placed on traditional services by vast distances and difficult terrain. The technology will bring significant benefits to schools, the tourism industry, and isolated farming communities, as well as government and parastatal organisations.

The projects above are initiatives to take ICT to the rural communities and suggest that ICT can be used in every sector for socio-economic development. It also points out that if all stakeholders are willing to participate, the battle can be won.

4.0 General Conclusions and Recommendations

4.1 Conclusions

There are common problems that are encountered by both teaching and research in Botswana which are also common to other SADC countries. These are mostly compounded by the fact that:-

- The population of Botswana, even though small, is sparsely distributed and this has much effect on the distribution of the limited infrastructure.
- A large population of the target group that could benefit from the use and access of ICTs resides in the rural areas where most of the ICTs are not available. In cases where they are available, they are not easily accessible and/or in some cases not affordable.
- As in other SADC countries, people living in the rural communities would prefer other facilities above ICTs because they are mostly illiterate, poor, and therefore their immediate needs include food, housing, health care issues eg. HIV/AIDs etc.

- The high cost of hardware and software as well as basic telecommunications.
- Lack of electricity in many rural locations and high telephone bills for internet usage.
- Inadequacy of local training institutions in the area of ICT at advance level especially in areas such as network security and internet technologies.
- Connectivity problems still exist pending the on-going plans to link the country with East African and under sea cables. This will help solve the problem of bandwidth.
- Fragmented government and private sector databases.
- The lack of expertise in areas of hardware repair and maintenance and software development to meet the local need.

4.2 Recommendations

- The draft National ICT Policy must be accepted in Parliament for implementation. This would then empower the Monitoring and Evaluation Committee to ensure that different Ministries, Parastatals, Legislature and the Private Sector play their role to ensure commitment and participation in developing and implementing their own institutional policies.
- All higher education institutions should develop their own policies. These must be supported from the leadership and consequently cascaded down to students.
- Higher education institutions should not only share experiences amongst themselves, but should also be examples to junior schools.
- As a nation it is crucial to encourage learning and teaching of science from primary schools when children are still young and receptive.
- Dissemination of use of ICT and its benefit in education must aggressively be undertaken in rural areas through workshops and seminars even in '*kgotla*' (cultural) meetings. This can be achieved if the local structures are involved and sold to the development.
- There would be a need to build a critical mass of technicians who would maintain and repair the technologies.
- All the above cannot be accomplished overnight because it is a complex and demanding process and therefore will need the commitment of every sector.
- While we deploy ICT across our nations we should also think of "*Management of Electronic WASTE.*"

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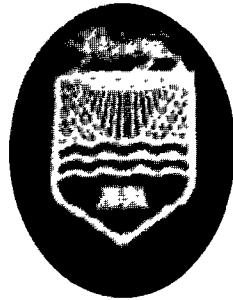
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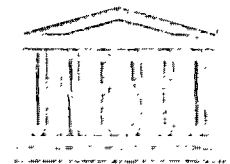
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Executive Summary

This paper discusses the status and use of ICT in Science and Engineering in higher education in Malawi focusing on the University of Malawi. In addition, it discusses the challenges to be learned from the achievements thus far, in order to map the way forward.

Higher education in Malawi consists of Universities, Teacher Training Colleges, Nursing Schools, Natural Resources Colleges/Farm Institutes, Technical Colleges, Theological Colleges, Secretarial Institutions, Computing Colleges and a number of private Institutions offering courses ranging from Computing, Business Studies, Corporate Governance, and many more. Most of these higher education institutes use computers.

The University of Malawi, which was established in 1965, is based on a federal structure, with a Central office and 5 colleges: Chancellor college, Polytechnic, College of Medicine, Bunda College of Agriculture and Kamuzu College of Nursing. The colleges offer various courses, which include science and engineering.

In pursuit of its academic objectives, the University of Malawi faces several challenges including inadequate and unstable funding, high demand for university places, and a shortage of well-qualified human resources. The University has nevertheless responded to some of the challenges through distance and e-learning, parallel programmes, use of ICT and formulation of relevant policies.

In Malawi, access to ICT is very low and concentrated in urban areas. However, through a National ICT policy, the government of Malawi aims at transforming Malawian society and the economy into one which is information and knowledge-based. In addition, among other things, the policy provides for improvement of education institutions through ICT and improvement of the ICT sector using higher education institutions. Similarly, the University of Malawi recognises and exploits the symbiotic relationship between higher education institutions and ICT. To this end, the University of Malawi uses ICT to enhance the institution, its activities and processes. On the other hand, the university is being used to increase awareness, skills and expertise in the ICT sector. In particular, ICT in Science and Engineering is used to model and analyse systems, simulate systems, calculate and solve engineering and scientific problems, and capture and explore experimental data.

Having said that, ICT in the University of Malawi faces several challenges including inadequate resources such as bandwidth, hardware and software, lack of policies to guide development and exploitation of ICT, and limited ICT awareness and skills. Therefore, in order to realise the potential of ICT, the university should formulate an ICT policy, train staff members in the use of ICT, and provide a conducive environment where novel ideas are harnessed and exploited.

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1 Introduction

It is now widely recognised that in education, Information and Communication Technology (ICT) holds the promise of transforming learning in new and powerful ways. It allows for a wide range of people to access the content needed to improve their knowledge and professional skills without having to travel distances to school or college. Despite socio-economic problems in recent years, such as the poor national economic performance, weak internal management systems, inappropriate governing structures, weak infrastructure, many institutions of higher learning in sub-Saharan Africa have attempted to exploit opportunities offered by ICT in teaching and learning. These opportunities have been exploited at all levels, from primary to higher education. Malawi's education starts at pre-school level, proceeding to primary, secondary and tertiary. Most of the schoolgoing population has primary level as the entry point, whilst a few have the opportunity to start at pre-school level. Research has shown that the younger a person starts, the more he or she can learn and grasp new concepts. Unfortunately, in Malawi the reality is different. Children are rarely exposed to ICTs in schools at primary level, and only a few secondary schools have ICTs. This paper therefore discusses the status and use of ICT in Malawi in higher education (tertiary level) and discusses the challenges, in order to learn from the achievements so far, so as to map the way forward. The paper starts by describing the situation of higher education in Malawi, then reviews current status of ICT in Malawi in general and ICT in Science and Engineering in the context of higher education, particularly in the University of Malawi. The challenges are discussed, followed by suggestions on the strategies and methods that may address the challenges faced.

2 Higher education in Malawi

The higher education system in Malawi constitutes universities and a number of other tertiary institutions. These include, Teacher Training Colleges, Nursing Schools, Natural Resources Colleges/Farm Institutes, Technical Colleges, Theological colleges, Secretarial Institutions, Computing Colleges and a number of private Institutions offering courses ranging from Computing, Business Studies, Corporate Governance, and many more. Most of these higher education institutes use computers. However, although there seem to be numerous institutions of higher learning, demand and supply levels do not match. In the case of government institutions, supply depends on space (ie. bed space, classroom space), whereas with the privately owned institutions, other factors have to be considered, such as cost.

2.1 Universities

Malawi has two public and two private universities. Up to the 1990s, the country had only one university the University of Malawi. This, the first public university in Malawi, was established in 1965. Mzuzu University is the second public university, and was established in 1998. The two private universities are Livingstonia University (established in 2003) and Catholic University (established in 2005).

The University of Malawi has a federal structure, with a central office in Zomba and 5 colleges: Chancellor college in Zomba, Polytechnic in Blantyre, College of Medicine in Blantyre, Bunda College of Agriculture in Lilongwe and Kamuzu College of Nursing in Lilongwe and Blantyre. Each college has its own academic focus. For example, Polytechnic focuses on Information Technology, Engineering, Commerce, Applied Sciences, Education, and Media Studies. Chancellor College focuses on pure Sciences in the faculty of Science - which includes Computer Sciences; Social Sciences and Political Science in the faculty of Social science; Education faculty; Arts in the faculty of Humanities; and Law in the faculty of Law. College of Medicine offers medical courses, which include community health and medicine. Bunda College of Agriculture offers agricultural related courses such as irrigation,

agriculture engineering, environmental, animal and crop science courses etc. Finally, there is the Kamuzu College of Nursing.

Mzuzu University offers education courses both science and humanities and health and environmental courses, and Livingstonia University has started with education courses.

2.2 Other Tertiary Institutions:

There are three other institutions that offer degree programs: these include the National College of Information Technology (NACIT), privately owned Share World, African Bible College (ABC), and CBET owned by BUMAS International. The government of Malawi through the department of Information and Tourism owns NACIT. In addition, Malawi has other institutions offering higher learning which include: the Domasi College of Education (DCE): an institution that trains secondary school teachers to Diploma level; several Teacher Training Colleges (TTCs) spread across the country: some government owned, others owned by Churches and NGOs such as the Humana from People-to-People. Technical Colleges (Technical and Artisan Training), Malawi Institute of Education, Nursing and Health Sciences Schools, Theological Colleges are others. The country also has privately owned institutions of higher learning, which offer courses ranging from Management, Corporate Governance, and Information Technology. The trend is that more and more Institutions offering information technology are emerging.

Educational Challenges of University of Malawi

In the early years, the University of Malawi was funded mainly through donor financial support, and was well supplied in terms of books, laboratory equipment and materials. However, in the early 1990s, the donors reduced funding to Malawi, which meant that funding to the University was also affected. Currently, the University is funded mainly through the government of Malawi subvention. This source of income is unreliable and most of the time inadequate. This has negatively affected the teaching and learning activities in the University of Malawi. The areas that have most been affected by low funding levels are science and engineering. Courses in these areas are expensive to run because they require expensive laboratory equipment and materials for experiments and practicals. Furthermore, textbooks used in Science and Engineering courses are generally expensive. The result is that the courses in science and engineering, once interesting because of the laboratory experiments, have been reduced into a series of lectures; consequently, the courses in science and engineering have become abstract.

Recently education policies have tended to focus on primary and secondary education and have failed to acknowledge the role of ICT. This means that most of the Government of Malawi resources earmarked for the education sector are channelled to primary and secondary school levels activities and programmes.

Thirdly, demand for higher education is greater than supply, which is normally determined by bed and or classroom space. For example, of approximately 4300 students who qualified for university education in 2005, only 20% were admitted into the University.

Finally, there is a shortage of human resources due to the brain-drain and the HIV and AIDS epidemic. Some lecturers, once trained, leave the university of Malawi for greener pasture in other universities in the region or overseas. Furthermore, the University of Malawi loses many well-qualified lecturers to AIDS related deaths.

The University of Malawi has responded to some of the challenges in various ways. Firstly, the University offers some of its programme through distance education. More recently, the university

has started offering some courses through e-learning. For example, the Malawi Polytechnic has introduced a diploma programme in Transportation operation and Management under the NeTTom programme and has proposed to start a postgraduate diploma in ICT management in 2006 under the NeTTel programme. This enables it to extend access to university education to those who would otherwise be unable to access university education because of limited bed and classroom places, or because they are working and cannot attend classes.

Secondly, the University of Malawi offers courses through a parallel programme. In this context, additional students are admitted into the university; however, the students are required to pay economic fees and do not occupy bed space. This has extended access to university education to a wide portion of the population and supplemented the university revenue, which is used to modestly supplement staff salaries and buy teaching and learning materials. However, the parallel programme has exacerbated the problem of classroom space.

Thirdly, the University of Malawi encourages the use of ICT in Teaching and Learning. To this end, lecturers at all the colleges use ICT in preparing and delivering lectures. Students, on the other hand, are encouraged to use ICT in their assignments and reports. Most recently, the University of Malawi has revived its University-wide ICT committee as a way of ensuring common ICT standards and policies within the University of Malawi.

Finally, the University of Malawi is in the process of formulating an HIV and AIDS policy that aims at mitigating the effects of the illness on university operations. The University also plans to include an HIV and AIDS module in the curricula for all its programmes.

3 ICT Situation in Malawi

ICTs are available mostly in institutions of higher learning and other organisations in urban areas. There is a shortage of ICTs in the rural areas where about 80% of the population resides. In cases where ICTs are available, either they are not easily accessible or they are not affordable. As a consequence, most people do not have access to ICTs because they are poor, illiterate, or have other more pressing needs such as food, housing, and health care, including the HIV and AIDS pandemic.

In terms of access, in a country with a population of about 12 million, there were only 85000 telephone lines, 135100 mobile phone subscribers, and 36000 Internet users recorded in 2003. These figures indicate that only 1.1% of the total population had mobile phones, and only 0.3% of the country's population had access to the Internet by 2003. In the case of the telephone lines, although the number indicates that only 0.7% of the population have access, this percentage could be higher considering the fact that several people might share one telephone line. But even if each telephone line were to be shared by ten people, only 7% of the population would have access, which is still very low. The non-availability of the ICTs is mostly due to lack of the core infrastructure, such as power supply and telephone lines, particularly in the rural areas. In areas where the power supply is present, it is unreliable, especially during the rainy season, due to frequent power cuts, and these tend to sabotage ICT projects implementation, which are largely electricity-driven. The life span of ICT equipment is also adversely affected by these blackouts because of the fluctuations in power levels.

3.1 ICT National Policy

The Malawi national ICT policy has been drafted and is still under discussion. The policy was formulated through a nation-wide consultative process involving key stakeholders in the public sector, private sector and civil society reflecting the nation's commitment to pursue an ICT-led socio-economic development agenda. The policy takes into account the aspirations and provisions of key

socio-economic framework documents including the Vision-2020, Malawi Poverty Reduction Strategy Paper (Ministry of Finance and Economic Planning 2002), communication sector policy, and Malawi Science and Technology Policy statement (National Research Council of Malawi 2002).

The mission of the ICT policy is to transform Malawian society and the economy into a predominantly information and knowledge-based middle-income economy by modernising its key development sectors using ICT (Ministry of Information and Tourism 2005).

In order to achieve its mission, the policy pursues goals targeting the following:

- (A) developing Malawi's information society and economy,
- (B) pursuing a multi-sectorial ICT-led Socio-economic development; and
- (C) developing Malawi's ICT sector.

The policy statement recognises the role that ICT plays in higher education on the one hand, and the role higher education institutions play in popularising ICT on the other. In this regard, among the 14 pillars of the policy, accelerated human resource development and promotion of ICT in education are ranked highly.

The policy, therefore, has put in place several strategies that aim at deploying and exploiting ICT to support the delivery of education among other developmental sectors.

Firstly, the Malawi government aims at modernising Malawi's education system using ICTs to improve and expand access to education, training and research resources and facilities; improve the quality of education and training; and make education systems responsive to the needs and requirements of the economy and society. Furthermore, the policy aims at developing educational management and information systems to improve the quality of management of education institutions.

Secondly, the policy promotes electronic distance education and training and virtual learning systems to complement and supplement face-to-face campus based education and training systems; leverages the use of electronic distance learning networks to enhance the delivery of education; encourages e-learning by promoting Internet access to all educational institutions including schools, universities and colleges; and ensures that all universities and colleges take steps to progressively offer their programmes and courses online to broaden access to higher education to a large section of the population; thus maximising the quality and efficiency of the learning process, systems and activities.

On the other hand, the policy has identified higher education institutions as part of key implementation agencies, players and stakeholders. Towards that end several strategies are spelt out in the policy document that use higher education institutions to support ICT.

Through institutions of higher education, the Government of Malawi aims at having an economy based on a literate society with a high proportion of computer literates; an economy characterised by a technology-based knowledge driven industrial sector backed by cutting-edge research and development activities. Furthermore, the government of Malawi encourages higher education institutions to develop ICT training programmes for management and staff of Ministry of Education institutions at all levels.

Secondly, the policy aims at promoting basic training in ICT skills in tertiary institutions; transforming Malawi into an information and knowledge-driven ICT literate nation; promoting ICT awareness and computer literacy in the public at large, and developing and restructuring the relevant ICT curricula for all levels of education.

Thirdly, it aims to develop human resources to support the deployment and rehabilitation of modern state-of-the-art ICT infrastructure.

Finally, through the policy, the government of Malawi aims to support and strengthen scientific research and development in the nation's universities and research institutions as basis for promoting the development of a globally competitive local ICT sector and industry. In addition, it aims to encourage and fund ICT Research and Development (R&D) in the nation's colleges and research institutes and set up special libraries for various people to access and utilise them.

3.2 ICT in Higher Education

The University of Malawi recognises and takes advantage of the symbiotic relationship between ICT and Higher education. In this context, ICT has been used to enhance educational institutions, activities, and processes; the University has also been used to increase awareness, skills and expertise related to ICT.

3.2.1 ICT as a Tool for Higher Education

In general, ICT is used to enhance educational institutions, in order to optimise utilisation of resources, maximise the quality and efficiency of the learning process, systems and activities.

Firstly, ICT is being used to effectively manage the educational activities. Towards that end, constituent colleges use ICT to manage students' records, human resource records and accounting information. However, colleges have developed such information systems without coordination, making sharing of information difficult. In addition, the University provides ICT to facilitate effective and efficient communication. Yet, most communication within the University is done with printed paper.

Secondly, lecturers and students use ICT in all colleges to search for teaching and learning materials, and research information on the Internet. In addition, lecturers and students use ICT to access Library information, online databases and journals (such as HINARI, PERI, JSTOR) at all college libraries, with varying degrees of competence.

Thirdly, students and lecturers use ICT in teaching, learning and research activities. For example students use packages such as Matlab, MathCAD, SPSS, AutoCAD, VISIO and programming languages such as C, C++, PASCAL, JAVA, VISUAL BASIC in their education activities. Common packages such as Microsoft Office are used to prepare teaching and learning materials, reports and presentations. The College of Medicine has adopted a method whereby lecturers are encouraged to have their notes in electronic format, stored on a central server. This enables students to access the notes any time, and enables the lecturer to update the notes easily. They are also moving towards bringing technology into classrooms (having fixed computers and overhead projectors) so that the lecturer doesn't have to use chalk and dusters.

Fourthly, ICT is used for extending the reach of University programmes through e-learning. As stated earlier on, the Malawi Polytechnic has introduced two distance education programmes through e-learning, namely: a diploma in Transport Operations and Management under NeTTom and a postgraduate diploma in ICT management under NeTTel. In addition the Bunda College or Agriculture, the Polytechnic and Chancellor College act as CISCO academies where courses under the CISCO curriculum are offered through e-learning.

Finally, ICT is used in Research; for example Chancellor College has a Wireless Technology Research Group looking into the use of wireless technology in the Health sector

3.2.2 Higher Education as a Tool for ICT

Higher education institutions can be used to popularise ICT in general. Towards that end, the University of Malawi has encouraged the inclusion and use of common computer packages (MS Office packages: Excel, Word, PowerPoint) in the curricula for most programmes in all colleges. The idea is that once the graduates leave university, they should continue using computers in their various activities. In other words, ICT should be integrated in the students' normal working habits.

The university has approved programmes that train students in Computer Science at Chancellor College, and Business Information Systems, and Information Technology at the Malawi Polytechnic. These programmes provide the much needed expertise and skilled human resources necessary to support ICT in the country. Furthermore, the University of Malawi is part of the National Research Education Network (NREN).

Finally, some programmes include ICT as a tool that supplement different courses. For example, AutoCAD is highly used in Architecture, Mechanical and Civil Engineering courses; Matlab is used in Electrical Engineering, GIS and remote sensing is used in Land Surveying and Geography, and SPSS in Social Science.

3.3 ICT in Science and Engineering

In the University of Malawi, ICT is used in various ways, mainly as a tool that supplements traditional face-to-face teaching and learning of Science and Engineering. The usages identified are as follows:

- (a) ICT is used to model engineering and scientific concepts and systems in order to develop and encourage an understanding of science and engineering. For example, students at the Malawi Polytechnic use AUTOCAD, Electronics Workbench, Microsim, PSPICE and Matlab to model and analyse engineering systems.
- (b) ICT is used to capture and explore experimental data. In this regard, data-loggers are used to collect data; and using charting tools in Ms Excel, Matlab, and SPSS, graphs are plotted to display distributions and patterns; and compare various performance scenarios of Scientific and Engineering systems. For example, at Bunda College, data-loggers are used to collect data on animal and crop science related courses and research while data loggers are used for energy audit and management projects at the Malawi Polytechnic. At Chancellor College ICT is used in data manipulation and in physics and mathematical modelling. Furthermore, personal computers coupled with appropriate transducers and actuators are used as measuring instruments such as oscilloscope, voltmeter, spectrum analyser, and function generator.
- (c) ICT is used to calculate and solve engineering and scientific mathematical problems. In this regard, computer packages such as MS Excel, Maple, Mathematica and MathCAD are used. In some cases, special programs are written in C/C++, PASCAL, and Basic to solve Scientific and Engineering problems. At Chancellor College, ICT is used to develop software both as part of a course or for use at institutional level.
- (d) ICT is also used to simulate scientific and engineering systems and consequently experiment with the simulation models. The models are used for research as well as teaching and learning activities.
- (e) ICT is used to support the teaching of science and engineering. In this regard, practical sessions, demonstrations or field trips are recorded on videotapes and then played back to

students. In addition some of the lessons are on videotapes and DVDs. Using the audio/video rooms mainly in college libraries, students can watch the tapes at their convenient time. This is mainly used in nursing, medicine, engineering processes, chemical processes, animals and crop sciences courses.

4 Challenges

There are a number of challenges confronting realisation of ICT in higher education, particularly science and engineering.

Firstly, the University has not formulated a policy on ICT; and apart from College of Medicine, no college has prepared its ICT policy to guide the development and utilisation of ICT. The implication of this is that most networks in University of Malawi colleges evolved in an ad-hoc manner without coordination making sharing of information and resources very difficult. In addition, there is a lack of properly documented inventory for ICT resources. This makes sharing of experiences of success stories on the use of ICT very difficult.

Secondly, most colleges have very limited bandwidth affecting Internet connectivity. In some cases the limited bandwidth is due to the fact that the Kbps available are not enough, where as in some cases it is due to bottlenecks caused by viruses and spam. Coupled with limited bandwidth, there is a limited number of workstations and peripherals, and powerful servers to support the demands of ICT within colleges. The traditional mindset of depending on donors for financial and material support blinds the University to opportunities available within the institutions themselves.

Thirdly, there is lack of Integrated Tertiary Software for use in tertiary institutions in the country in general, and in the colleges of the University of Malawi in particular. This makes it difficult to share information and resources. Furthermore, acquisition of proprietary software is very expensive as each college or institution does it separately. In addition, most people have a feeling that the quality of open source many not be comparable to proprietary software.

Finally, although ICT has been part of the University system for some years, there are still many in the University who are not really aware of the potentials of ICT. Furthermore, university traditionalists are less willing to take up the opportunities that ICT offers.

Having identified the challenges faced in the University of Malawi regarding ICT, we make the following suggestions as a way forward.

- (a) A University-wide ICT policy should be formulated that should consider provisions in the National ICT policy and take on board aspirations of various colleges in the University. The University-wide policy should therefore benchmark policies for various colleges in the University.
- (b) ICT training should be part of staff development programmes so as to increase the awareness and skills in the use of ICT in Science and Engineering.
- (c) Workshops should be organised frequently where success stories of ICT use in colleges, country, and region, are shared. This may raise the confidence of other institutions in the use of ICT. Coupled with the sharing of experiences, pilot studies in the use of ICT in various disciplines of the University of Malawi should be conducted to demonstrate appropriate and relevant use of ICT in Science and Engineering.
- (d) Dissemination of information through discussion forums, knowledge bases, list-groups

should be encouraged where cases studies of how ICT has been effectively used to enhance educational institutions, activities and processes could be deposited and discussed.

- (e) The university should explore means on how it can integrate its resources to acquire large bandwidth, software and hardware by exploiting economies of scale. Furthermore, it should consolidate its position in society in order to influence government of Malawi policies that are conducive to the development of the university in general and ICT sector in particular.

5 Concluding Remarks

The paper has discussed the status and use of ICT in Science and Engineering in higher education in Malawi focusing on the University of Malawi. It has furthermore discussed the challenges so that we learn from the achievements and challenges in order to map the way forward.

In Malawi, access to ICT is very low and concentrated in the urban areas. However, through a National ICT policy, the government of Malawi provides for improvement of education institutions through ICT on one hand and improvement of ICT sector using higher education institutions. Similarly, the University of Malawi recognises and exploits the symbiotic relationship between higher education institutions and ICT. To this end, the University of Malawi uses ICT to enhance the institution, its activities and processes. On the other hand, the university is being used to increase awareness, skills and expertise in the ICT sector. In particular, ICT in Science and Engineering is used to model and analyse systems, simulate systems, calculate and solve engineering and scientific problems, and capture and explore experimental data.

The University of Malawi has made these achievements in the presence of several challenges including inadequate resources such as bandwidth, hardware and software, lack of policies to guide development and exploitation of ICT, and limited ICT awareness and skills. However, in order to realise the potential of ICT, the university should formulate a ICT policy, training staff on the use of ICT, and provide a conducive environment where novel ideas on the use of ICT are harnessed and exploited.

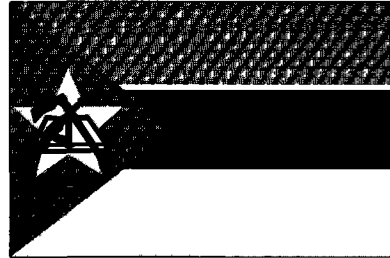
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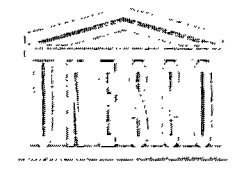
Information Communication

Technology in

Mozambique

Prepared by

Sérgio Machado



I. Introduction

Information Communication Technology (ICT) was introduced in Mozambique in an uncoordinated manner as a result of the absence of a national policy. The government, thereafter, applied unprecedented efforts for the rapid and effective adoption of a national policy. On 30 May of 2000, Mozambique's National ICT Policy was approved by the Council of Ministers.

The adoption of this policy made ICT the motor force of various aspects of Mozambique's development. The main objectives of the policy are:

- To raise the national level of knowledge as to the role and potential of ICTs in the sustainable development of Mozambique;
- To contribute to the eradication of absolute poverty and improve living conditions;
- To provide universal access to information to all citizens in order to improve their level and performance in education, science and technology, health, culture, entertainment and in the workplace;
- To expand and develop the teaching of information technology in the National System of Education;
- To encourage and support Informatics training for directors, community leaders, women, young people and children;
- To contribute to the increase in efficiency and efficacy of the public and private sectors;
- To contribute to the effort to make the country a producer and not merely a consumer of ICTs;
- To create a favourable climate for industry, business and investment in the area of ICTs;
- To ensure that plans and development projects in all sectors have an ICT component;
- To contribute to the reduction and gradual elimination of regional imbalances, the differences between city and countryside, and between the various segments of society in respect of access to opportunities for development;
- To create a favourable environment for cooperation and partnership in ICTs between the public and private sectors and between all stakeholders at national, regional and international level; and
- To empower and facilitate the integration of the country in the world economy and in the Global Information Society. (Opuku)

Mozambique's ICT policy is wide-ranging, with six priority areas that are: **Education, the Development of Human Resources, Health, Universal Access, Infrastructure, and Governance (Opuku)**. The benefits of the use of ICT are being felt in all these areas: the creation of telecentres and implementation of information systems in the Eduardo Mondlane University and other Universities, forming ICT skilled personnel, creation of the CD-Rom on malaria, development of Community Multimedia Centres throughout the country, installing a National fibre backbone and creation of citeNet. These and others ICT advances will be further discussed throughout the report.

II. Current Status of ICT Policy

Implementing ICT in Mozambique is an immense challenge because of its demographics and the inadequate electricity and telecommunications infrastructure. Stakeholders and potential beneficiaries such as state institutions and non-governmental organisations, teaching and research institutions, public and private sectors and the general public, have ensured the success of the ICT policy by actively participating in policy application.

The high level of illiteracy in the country constitutes a challenge for the application and expansion on ICT Table 1.

Demographics of Mozambique

Geographical position: Southern Africa

Neighbouring countries: Tanzania, Malawi, Zambia, Zimbabwe, Swaziland, and South Africa

Land area: 799,380 square kilometers

Population statistics (2003)

Total: 17,479,266

Population growth rate: 0.82%

Males per 100 females: 0.96

Age: 42.1% (0-14 yrs) , 55,3% (15-64 yrs) , and 26% (64 and older)

Where the people live

In cities: 29%

In the countryside: 71%

Literacy rate (2003)

Total: 47.8%

Male: 62.5%

Female: 32.7%

Life expectancy at birth (2003)

Average: 31.3 years

Males: 30.98 years

Females: 31.63 years

Gross National Product: 4.5 billion US dollars (2001)

Human Development Index: 0.322 (UNDP 2000)

Ranking in HDI: 170th in 174 countries (UNDP 2000)

Source: Wikipedia and UNDP

A major part of the population of Mozambique is rural and illiterate, and this constitutes a great challenge. On one hand, it is difficult to implement ICT in the rural areas due to lack of electricity and telecommunications infrastructure; on the other hand, the lack of human resources, especially skilled personnel is also a major issue for the Mozambican government.

Basic ICT training is provided by a small number of schools, telecentres, community access centres and private businesses. So far, only 30 to 40 students have graduated with technical ICT skills

throughout the country. Postgraduate programmes and a number of scholarship programmes are available in collaboration with external universities. In the field of computer science there is virtually no training offered in the country. Thus, the ICT policy has implemented a strategy to address the demand for skilled ICT personnel (including people with skills in systems engineering and analysis, network engineering, design and development of data bases, maintenance skills, systems for quality control, data input, software development, etc). Mozambican institutions and individuals are now able to acquire ICT skills and knowledge from the public and private sectors (Opuku).

The amount of informatics equipment has increased countrywide, particularly in the larger cities. In 1999 there were 10 000 internet users and in 2002 there were 60 000 users; 80% of whom are in Maputo, the capital city. The backbone of the National Transmission Network was concluded with the construction of a submarine fibre optic link between Maputo and Beira with intermediate connection points in Xai-Xai, Inhambane and Vilanculos along an extension of nearly 1,000 km, with a 2.5 Gb/s capacity per pair of fibres in 2002. Other gateways and government networks were and are being installed in Beira, Nampula, Pemba and Quelimane (Alba). Efforts are being made to expand the programme to other provinces and some smaller towns.

Allied to the gradual introduction of telecentres and other community access points, the expansion in the number of Internet cafés and digital agencies is behind today's increase in the numbers of people that access the Internet in the country.

All these advances and figures show how far along the way Mozambique's ICT policy has traveled. Despite all the limitations, technical problems, human capacity problems, financial and infrastructural problems Mozambique continues to implement its ICT policy project and is strategically creating means for popularization of ICT use.

III. The Incorporation of ICT

Some policies, currently embodied in laws, constitute a barrier to the incorporation of ICT in Mozambique. Policies dealing with telecommunications networks and services such as Law 14/99, the Telecommunications Act, decrees and ministerial dispatches, and regulatory provisions that establish basic principles of operation, allocate resources to encourage particular developments, and spell out the scope for action, are most relevant to the development of ICTs. The Mozambican telecommunication (TDM), the national telecom operator is a public company, and is the sole provider of basic domestic voice services over fixed wire networks for a period fixed by law (Manhiça).

This is just one example of the many policies and laws that make the incorporation of ICT a slow process. Policy and Legal changes are needed in a number of other areas in order to facilitate the effective use of the infrastructure. These areas include electronic commerce, intellectual property, privacy and security as well as international commerce.

The government is committed to Mozambique joining the Global Knowledge Society, recognises the importance of ICTs to sustainable development, and has a clear vision for the integration of ICT in national development as articulated in the ICT Policy. Changes are being made in the policies and laws to ensure the proper implementation, incorporation and use of ICT. Most applications of ICT in government are directed at management, financial and administrative processes. Here are some examples:

- Today most provincial governments are now connected to the Internet, and their governors are active users of e-mail.
- Private companies have established on-line news and information services and compilations of official information and legislation in electronic format on CD-ROM. A

Country Development Gateway is being developed through partnerships between the private and public sectors.

- The Ministry of Science, Technology and Higher Education has set up a network (CiteNet) that will be used for debate and formulation of policy during this first phase of the process, and afterwards, to dynamise the implementation and monitoring of the approved policy (Manhinça).

The Ministry of Science and Technology does not measure efforts towards the implementation of the National ICT policy due to the fact that ICT is part of its Eradication of Absolute Poverty plan.

IV. ICT in Education

ICT is being used to a great extent as a tool in education in general and in higher education. Advances are being made in order to increase the use of ICT as an important tool in teaching and learning.

1. ICT in Higher Education.

The Eduardo Mondlane University (EMU) has already implemented some management information systems, though they need an upgrade or reformulation. These systems are an academic records information system, and a human resource and payroll information system. EMU is also in a process of acquiring a financial information system. These facilities allow the university to have minimum access to information technology resources for improved teaching and learning mechanisms as well as administration and management. By the end of this year the following ICT infrastructure and services will be available at **EMU**:

- A 100mbps fibre (that can be operated at speeds as higher 1gbps) will be available in the main campus as a backbone. This fibre will connect the following faculties and units: the Faculty of Science, Arts, Economics, Agronomy and Forestry Engineering, Social Science Unit, Centre for Informatics, Centre for African Studies, University Press, Directorate for Administration and Assets, Directorate of Documentation Services, Directorate of Finance.
- A 100Mbps fibre backbone in the Faculty of Engineering connecting the following departments: Department of Electrical and Electronics Engineering, Civil Engineering, Mechanical Engineering, Chemistry, former Physics and Chemistry buildings, Geology, Production Unit, Woodwork, building and the Centre for Electronics and Instrumentation.
- Wireless backbone running at 11mbps in the backbone and 3mbps for site connections. This wireless network will connect the following units of EMU: Faculty of Engineering, Veterinary, Medicine, Law, Architecture, DSS, ISATEX, R5, R6, R7, 33° floor building, Mozambique Historical Archives, Museum of Natural History.
- Complete structured internal local area networks in the following faculties: Faculty of Science, Engineering, Economy, Arts, Unit of Social Science, Basic Science Project (BUSCEP), Centre for African Studies and the Department of Mathematics and Informatics.
- Small Local Area Networks typically in a computer laboratory with an average of 12 points each. Networks have been setup in the following units: Faculty of Law, Veterinary, Architecture, Agronomy and Forestry Engineering, Department of Chemistry, Biology, Physics, Geology, Mozambique Historical Archives, Directorate of Finance, Directorate of Social Service, R5, R6, R7.
- UEM (Eduardo Mondlane University) has developed proposals for a Mozambique ICT Institute (MICTI) that includes research and training, establishment of small businesses, a n d

the creation of a science park. The programme will draw on national and international business and academic partnerships to develop high-level ICT knowledge and skills to address the goals of development and strengthen the Mozambican ICT business sector.

- EMU-Sida/SAREC IT Project. This project aims to improve and expand the existing ICT infrastructure at the EMU in the framework of the university-wide ICT project called NET (Eduardo Mondlane University Network) and create complementary capacities to enable the teaching/learning processes to take advantage of the ICT resources. Besides the networking component, the project will also consist of a capacity building component, involving specific training for network administrators and postgraduate studies in the field of ICT.

- **Developing Local Area Networks (LAN's)** In this new proposed project the aim is to install a complete network infrastructure (cabling and equipment), that is regarded as being the final stage in the installation of a local area network in that particular building. All networks will have access to the Internet through a common gateway.

- **Internet Bandwidth upgrade** With the installation of fibre backbones and wireless links connecting the existing LANs, Internet usage at EMU will increase greatly. With the establishment of NET it is expected that usage will explode. The currently existing bandwidth no longer satisfies the needs of EMU as well as the needs of the other entities that CIEMU provides services to. Provision should be made to improve the bandwidth to Internet to at least 1mbps duplex link, i.e., 1mbps for uplink and downlink.

- **Multimedia laboratory** With the current existing infrastructure EMU should enjoy the benefits of IT for improving the teaching and learning processes. The multimedia laboratory should enable lecturers and researchers to prepare material that can be delivered electronically and interactively. The Laboratory should be equipped with computers, digital cameras, voice-recorders, video-recorders and other multimedia equipment that will enable the lecturers to produce CD-ROMs or websites that are sound and video enabled.

- **The Pedagogical University** has also made some improvements in the area of information technology:

- In Maputo it has opened an attractive Portuguese-language and literature library, which includes a multimedia computer and a link to the Internet.

- The Beira campus has computers, purchased primarily through project support. SIDA/SAREC funded the computer lab's printer and ten computers, of which only five are working. The computers are distributed as follows:

1. The maths department - six microcomputers as part of an ethno mathematics project;
2. The geography department has two PCs
3. The physics department has none.

- In Nampula, the Pedagogical University has one computer with a dial-up connection to the Internet using Teledata, which is used by many teachers.

- **The Higher Institute for International Relations (ISRI)** is located in two different buildings in Maputo. There are about 12 computers in the main ISRI building, all networked, and a few more in the second building. ISRI has a dial-up connection to the Internet. Instructors have access to two Internet-accessible computers; students can use the eight PCs in the computer lab or the computer in the

library. Private universities in Mozambique are also implementing information technology.

- **The Catholic University** ranks below EMU but above the rest of Mozambique's universities in terms of ICT facilities, except in the overall area of e-mail and Internet access: E-mail and Internet at Catholic University are restricted to dial-up connections.
- The Beira campus of Catholic University has a computer lab, with ten networked computers. Although the computers are fairly new, their capacity is low -- 16 MB of RAM and 1.5 GB hard drives.
- The Nampula campus has computer labs in the faculties of law and education.
- Catholic University has installed a sophisticated Geographic Information System (GIS) laboratory within the Centre for Investigation and Documentation for Integrated Development (CDDI) on the Beira campus.
- **The Instituto Superior Politécnico e Universitário (ISPU)** offers a number of degrees in the social sciences and technical subjects, including one in computer sciences, which provide for a major in either administration or telecommunications and new technologies.
- The Maputo campus is well-furnished in terms of information technology equipment. There is one computer lab with 10 PCs and a second multimedia lab with 15 computers, speakers, video equipment and an LCD projector. Internet services are free for students at ISPU. There are also three computers in the library. Lecturers sometimes request their students to use Internet on homework assignments.
- The Quelimane campus, which uses computers for the library and for administration, uses the same software as the Maputo home base and links to the Internet through Teledata. The Quelimane campus depends on teachers from Maputo who offer course modules lasting for one or two months. Students send their essays to Maputo, where they are corrected and returned. The Staff recognises that a consolidated e-mail system would facilitate this experiment in distance learning,
- **ISCTEM** runs courses in computer engineering and maintains an excellent laboratory with thirty networked computers. The library is fully computerised, and there is considerable awareness of the importance of ICT. ISUTC took in its first "zero year" students in 2000 and plans to specialize in computer studies with applications throughout the engineering subjects (Partnership).

Despite the many advances that have been made, many students in institutions of higher education are still unhappy with the state of their library and ICT facilities, because they have to wait in long queues to make use of these facilities.

ICT in General education

To increase the availability of ICT, Community Multimedia Centres (CMC) are being created throughout the country. The first CMC was inaugurated on 9 May 2005 in Xinavane. The CMCs combine community radio by local people in local languages with a community telecentre containing computers with Internet connection, phone, fax, email and photocopying services.

The CMCs are strategically located in or near an educational institution. The CMC at Xinavane is located in Xinavane Secondary School, and has created a CD-ROM on Malaria. This CD-Rom contains information about malaria in local languages. The CD-Rom will be used in the fight against malaria (UNESCO).

By the end of December 2006, Mozambique aims to establish 20 CMCs at district level. The number of CMCs is increasing and the following CMCs have already been set up:

- **Xinavane** (Maputo Province) xinavane@zebra.EMU.mz
- **Chókwè** (Gaza Province) telechokwe@telechokwe.org.mz
- **Moamba** (Maputo Province) cmcmoamba@zebra.EMU.mz
- **Ribáuè** (Nampula Province) teleriba@zebra.EMU.mz
- **Chiúre** (Cabo Delgado Province) telechiu@zebra.EMU.mz
- **Alto Molócuè** (Zambézia Province) telemolo@zebra.EMU.mz
- **Namaacha** (Maputo Province) telenamaacha@zebra.EMU.mz
- **Manhiça** (Maputo Province) telemanhica@zebra.EMU.mz
- **Sussundenga** (Manica Province) telesussundenga@teledata.mz
- **Dondo** (Sofala Province) tel:23-950473
- **Cuamba** (Niassa Province) cmccuamba@teledata.mz
- **Rádio Nova Paz** (Zambézia Province) novaradiopaz@teledata.mz (UNESCO).

Since ICT is still being incorporated in education, its use in teaching and learning has not yet been developed. The majority of schools in Mozambique do not even have basic equipment, such as chalk and blackboards; so, for the time being computer labs and ICT in the classroom lie far in the future.

However, the Ministry of Education (MINED) through its School Net programme and the Foundation for Community Development (FDC) are both carrying out programmes to extend connectivity to schools and to develop Internet based academic materials for teachers and students.

The Ministry of Science and Technology (MST) recognizes the importance of ICT in education. To stimulate an interest in ICT among the youth, the MST has created an Informatics Olympics, in which many Secondary Schools will participate.

From 18 to 22 April 2005, the MST in collaboration with the African Network Operators Group (AfNOG) and African Internet Protocol Address Registry (AfriNIC) organised a workshop where 75 African professionals, among them 25 Mozambicans, were trained in Internet services and net technologies. The participants are expected to extend their knowledge to others in their countries. Mozambique and Angola intend to organise a course for non-English speakers. The course will probably take place in Mozambique, in the north or centre of the country.

IV. Conclusion

Mozambique's ICT policy is wide-ranging with six priority areas that are: **Education, the Development of Human Resources, Health, Universal Access, Infrastructure, and Governance.** Means are being created to guarantee its use in many areas.

Mozambican ICT is for the most part in the implementation stage. The benefits of the use of ICT are

being felt in all the following areas: creation of telecentres and implementation of informatics systems in Eduardo Mondlane and other universities, training personnel skilled in ICT, creation of a CD-Rom on malaria, development of Community Multimedia Centres throughout the country, installing a National fibre backbone, creation of citeNet, etc..

The Mozambique government recognizes the importance of ICT as a tool to eradicate poverty and to improve education; therefore, the government, the private sector and the public in general are involved in implementation of the ICT policy and its use. The Ministry of Science and Technology is working in cooperation with other Ministries and non-governmental organisations in order to implement and popularise ICT use in the country.

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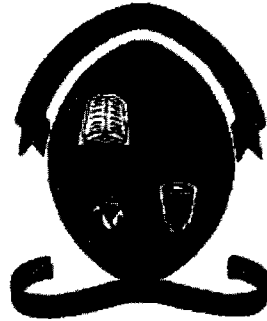
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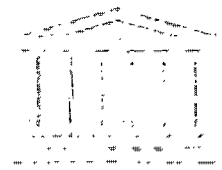


**The Use of Information and
Communication Technology in
Science and Engineering:**

***A Case Study of The
University of
Zambia***

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1 Introduction

There are two public Universities in Zambia, the University of Zambia (UNZA) and the Copperbelt University (CBU). There are also a number of private universities, research institutions, institutes and colleges. The University of Zambia is a multi-disciplinary institution while the Copperbelt University is a technology and business studies institution.

The University of Zambia opened in March 1966 with 310 full-time students. The University now admits about 6000 students a year on a full time study basis, but less than 500 study by Distance Learning.

In view of the economic importance of both the industrial and mining sectors, and because so much value is pinned on scientific and technological development, the Zambian government requires that the University gives priority to the sciences in terms of enrolment and allocation of resources. However, achieving this has not been easy because of the cost of developing and maintaining science-based fields of study. As a result of this the University has not yet succeeded in producing the number of Science and Engineering graduates that Zambia needs.

The government provides funds to the University of Zambia in the form of grants for running costs, student bursaries, etc. Over 90% of the University's income originates directly from public funds. The University's income has substantially increased in real terms regardless of the constraints on national resources. Although what the University receives constitutes a disproportionately large share of public funding for education it does not receive enough funds to enable it do its work effectively.

The University of Zambia has nine schools: Agricultural Sciences, Education, Engineering, Humanities and Social Sciences, Law, Medicine, Mines, Natural Sciences and Veterinary Medicine. Education, Humanities and Social Sciences, and Natural Sciences are admitting Schools. The School of Engineering draws its students from the School of Natural Sciences.

Like many University Libraries around the world, the University of Zambia library is responding to the dramatic growth of Information and Communication Technology (ICT). It is doing so by providing its users with CD-ROMs, E-journals, access to various databases, Special Collections, etc. The Special Collection Division is the main research wing of the University Library. Several categories form this division, including the Rare Book and Audio-Visual (AV) collections.

The growth of ICT at the University, from the early 1990s to date, has not been as rapid as one would have expected. In his welcoming speech to the first year students in February this year the Vice-Chancellor said, *"UNZA's infrastructure for ICT was quite advanced in the early 1990s relative to other Universities in the region. ZAMNET (Zambia's leading internet-service provider) was born at UNZA and remains a University of Zambia-owned company. It was one of the first internet-service providers in Sub-Saharan Africa north of the Limpopo. Moreover the campus was equipped by the mid-1990s with a state-of-the-art optical fibre network linking work stations all over the campus to the Computer Centre. However ICT is a very rapidly evolving field of technology and financial constraints have made it impossible for UNZA to maintain those early achievements in the last several years."*

In a bid to stay in step with the advancement in ICT in the region UNZA hosted a consultative meeting in May 2005 which was one of the key steps in the preparatory work that led to the recent launching of the Southern African Regional Universities Association (SARUA). The association is conceived as an output-based organisation that centres on four initial themes, two of which are:

- ICT preparedness and infrastructure development;

- Science and technology collaboration and innovation.

The University of Zambia hopes to make good use of this collaboration.

2 Status of National ICT Policy

The National ICT Policy is now at Cabinet stage. Presented here are a few features of the draft policy with regard to education.

2.1 Policy Goal

The goal of the Policy is to integrate ICTs in the Education system and develop the nation's Research and Development (R&D) capacity, to support, facilitate and contribute to the development of key sectors of the economy, including the development of appropriate local ICT products and services.

2.2 Commitments

In order to achieve the above goal, Government shall:

- (a) Facilitate the creation of Centres of Excellence for research in Electronic Engineering / Telecommunications, Computer Science / Information Technology, Media / Information Science, etc;
- (b) Take appropriate policy measures to facilitate and promote the integration of ICTs within the entire Zambian educational system to support administration, teaching, learning and research;
- (c) Adopt and adapt NEPAD E-Schools and other initiatives to promote E-learning and E-Education as well as life-long learning within the population at large;
- (d) Strengthen science and technical education as the basis for laying the foundation for human resource and skills development in ICT;
- (e) Adequately invest in R&D as a way of developing the nation's scientific and industrial research capacity in ICT's.

2.3 Objectives

- (a) To deploy ICTs at all levels of the Zambian educational system in order to improve and expand access to education, training and research facilities;
- (b) To modernise the educational delivery system with the aim of improving the quality of education and training at all levels;
- (c) To strengthen the administration and decision-making capacity in the educational system through the deployment of Education Management Information Systems;
- (d) To promote collaboration of R&D systems within the local industrial set-up to facilitate product development, innovation and delivery of world-class services that can compete on the global market.

2.4 Strategies

- (a) Promote and facilitate the integration of computer skills into the teaching and learning process at basic (primary), high school and tertiary levels;
- (b) Introduce programmes on teacher education in ICTs at all training institutions in the country;
- (c) Develop partnerships with the private sector and other stakeholders in the quest for increased ICT literacy;
- (d) Promote and accelerate the extension of tertiary education programmes at the nation's colleges and universities to teacher training colleges through E-learning systems;
- (e) Develop a national ICT curriculum and qualification system at basic, high school and tertiary levels;
- (f) Promote the development, deployment and utilisation of electronic-based distance education, training and learning systems in the Zambian educational system to complement and supplement residential education and training;
- (g) Promote and facilitate the development and adoption of Educational Management Information Systems in public and private educational institutions to improve the quality of managing educational delivery activities, operations and monitoring;
- (h) Promote and facilitate the participation of the private sector and other establishments including industries and businesses in industrial research as well as cutting-edge R&D activities;
- (i) Encourage and facilitate collaborative research; R&D projects and knowledge transfer partnership between Zambian universities/research institutions with counterpart institutions in other countries;
- (j) Implement special schemes, policy measures and packages aimed at promoting affordable acquisition of computers and other ICT products by students, trainers and educational institutions;
- (k) Promote and facilitate the adoption of educational technologies and Internet access within the public and private educational institutions targeting all levels of the education system;
- (l) Allocate a significant percentage of the national budget to integration and deployment of ICTs in the education system.

3 ICT in Science and Engineering

The University has a partner consortium of Universities in Belgium (VLIR), which supports the University's attempts to consolidate and expand the institution's ICT capacity. The Computer Centre has managed in recent months to significantly increase the Internet bandwidth accessible on campus with assistance through the VLIR partnership. This has greatly assisted the schools of Natural Sciences and Engineering both in research and teaching. Further progress is expected over the coming year.

3.1 Incorporation of ICT in the Science and Engineering policy of the Institution

The University as a whole does not have a clear ICT policy but several guidelines, such as the diversification of modes of provision, are outlined in the University Strategic Plan for the years 2002-2006. Some individual departments such as the department of Computer Studies have established ICT policy guidelines that are in line with the Strategic Plan. The department of Computer Studies is a relatively new department, offering various computer science-related course units. The department also offers a bachelors degree in Computer Science. One of the aims of the VLIR partnership programme is to support the Department of Computer Studies in offering programmes of study at BSc. and MSc. levels and, in the future, to PhD.

3.2 Use of ICT in the classroom

3.2.1 Science

Information and Communication Technology tools are utilised in several ways in the School of Natural Sciences. All the teaching in the Department of Computer Studies and some of the teaching in other departments is done using PowerPoint presentations and an LCD projector.

Nearly all the offices of the members of staff in the school have a PC with full Internet connectivity. The classrooms, in the Department of Computer Studies and some in the Department of Physics, are equipped with PCs, which also have Internet connectivity. This has made it possible for some lecturers to host websites that are locally available throughout the departmental Local Area Network (LAN). Through a few of these websites, assignments are given to students, announcements are disseminated, and students can use interactive discussion boards to discuss academic issues. Some course materials are also uploaded to the websites for students to download and print.

Most of the laboratory sessions in Computational Physics and Computer Science are hands-on exercises and students use their computers to carry out these exercises.

In the Department of Computer Studies, the integrated assets management system called Department Assets Tracking and Management System (DATAMS) is in the process of being implemented. It will be used to manage the assets of the department, which include a small library, devices like the LCD projectors, which are sometimes hired out, and also the laboratories and the seminar room. Students will also be able to access their accounts to check for academic information.

3.2.2 Engineering

ICTs are used to varying degrees as tools in all the five departments in the School of Engineering. The most commonly used package is Microsoft Office (Word, Excel, PowerPoint, etc) in the preparation of the lecture materials. The Internet is used as a great resource for current course materials.

Lectures are delivered mainly by use of transparencies that are photocopied from either PowerPoint or Word documents, and then presented using overhead projectors. In very few cases PowerPoint is used to deliver lectures using an LCD projector.

Other specialised software packages such as ArcView for Geographic Information Systems (GIS), ILWIS (Integrated Land and Water Information System), Macromedia Freehand for Map making are used during laboratory exercises.

The School, through the Department of Electrical and Electronic Engineering, is offering a Post Graduate Diploma in ICT Policy and Regulation by E-learning. The software used in this programme is an open source learning management software system called Knowledge Environment for Web-based Learning (KEWL). This web application was developed by the University of Western Cape in

South Africa and was recently upgraded to what is known as the KEWL Next Generation (KNG). A consortium of partner institutions of NetTel@Africa hosts this Post Graduate Diploma.

3.3 Use of ICT to Popularise Science and Engineering

3.3.1 Science

In the 1980s and early 1990s very few students opted to major in Physics. This was largely because the subject was viewed as being rather difficult and the course content (with the exception of the Electronics courses) was very theoretical and did not provide the graduate with enough practical skills to enter the increasingly competitive job market. In the last several years the Department of Physics has carried out several curriculum review exercises with a view to making the programme more attractive. To this end the content of existing courses has been updated and new courses including Applied Optics, Energy and Environmental Physics, and Computational Physics have been introduced. Of the new courses Energy and Environmental Physics has been very popular with the students but by far the most attractive course in the department is Computational Physics. This course has greatly helped in changing the face of the department from one that once registered between 3 to 6 second year students per year to one that now registers about 30. Probably as a result of the mentioned popularisation efforts, the department was proud to have produced its first female Physics Major student last year. This student has since joined the department as a Staff Development Fellow. Currently there are three female undergraduate students majoring in Physics.

It is worth noting that the Physics graduates have not had problems obtaining employment, because of the applied nature of the degree programme. Because of the Electronics and Computational Physics component of the programme, UNZA Physics graduates are serving as instrumentation engineers, computer hardware and software specialists, information technology experts, etc.

This year being the International Year of Physics, the department organised a public event to which government officials and members of various diplomatic missions were invited. At this event members of the Department of Physics gave talks to the general public on various aspects of Physics including Computational Physics. One of the aims of this event was to portray a more positive image of Physics as a subject with special emphasis on encouraging prospective female students, citing the recent trend of female involvement in the department.

There's very little that has been done to encourage female students into the Computer Science field at the University of Zambia. Despite this drawback the Department of Computer Studies is fortunate in that it also offers the Cisco Networking Academy Program (CNAP). Through CNAP, the department has acquired a new heavy-duty server machine, which is being configured. More female students have been enrolled in the department because of the CNAP policy, which encourages at least 33% female enrolment. The CNAP programme is free for students and the department therefore expects that as the programme grows more female students will become interested in the field of computer science.

3.3.2 Engineering

It has been observed that only a few female students opt to study Engineering. After entering the School of Engineering the majority of the female students opt for Electronic and Telecommunication Engineering. This specialisation employs ICT both as a teaching tool and as a subject. Other engineering disciplines are continually increasing the use of use of ICTs in order to make their programmes more popular.

3.4 ICT as a Subject in the institution

3.4.1 Science

The Department of Physics offers courses in Computational Physics and Electronics from the third year to post graduate level. The students therefore acquire skills in programming (mostly in C++) and complement these with Computer Architecture and Hardware Handling skills. The department has good computing facilities with a workstation for each student. The department also offers Energy and Environmental Physics courses in which students are taught elements of Computer Modelling and Simulation. Research projects are an essential component of the Physics programme. The department has on offer very challenging computer interface research work involving motivating applications of Electronics and Computational Physics. Students are readily able to work on projects like the automation of laboratory equipment because of the strong microprocessor component in the Computational Physics courses. Students that choose to do theoretical projects use various software packages such as Mathematica and MATLAB for their analysis.

ICT related courses are also taught in the Department of Computer Studies. Programming, Object-oriented Software Development, and Software Engineering, Database Management Systems (DBMS) and Networking are among the courses that are ICT related. At the final year level, the students carry out projects, which are mainly developing web-based Management Software Systems. One of the projects on the management of Student records is about to be adopted by the University Management. It is compulsory for any student accepted to the department to attend the computer appreciation course in which the students are introduced to the use of an operating system e.g. Windows and the packages from the Microsoft Office like Word, Excel, Access and PowerPoint for them to use in their studies. Assignments are only handed-in as typed material or as a soft copy. Students are also taught how to use the web browser, search engines and email facilities.

3.4.2 Engineering

There are full courses dedicated to introducing the use of ICT as a tool in Engineering and there are also courses that have components of ICTs. The components that are taught in the courses that are run in the five departments include the following:

- Introduction to Personal Computer (PC). Operating Systems and various Network Operating Systems;
- General concepts of Information Technology (IT), the importance of ICTs to an organisation, introduction to general software applications, PC hardware, networking, Database Management Systems (DBMS) web browsing, use of search engines and email facilities, classification of processors, communication protocols, system development, special purpose systems, communication concepts, linear modulation schemes, etc;
- Programming (application development software) in C++, Fortran, Turbo Pascal, Delphi and MATLAB; and
- Use of software packages such as AutoCAD, ArcView, ArcGIS, Columbus, LisCAD, ILWIS, GEOSECMA, and Macromedia Freehand are some of the , Pspice, Algor, 3-D modelling using Solid Works, etc.

4 Challenges

The graph below shows the number of first year student applicants to the University of Zambia in comparison to those selected and registered for the years 1998 and 1999. About 70% of the applicants were not selected in 1998 and over 40% in 1999. These percentages represent the general

range of the fall-out rate of applicants annually at UNZA. If the University had a larger enrolment capacity it would have accorded the opportunity to more eligible applicants to be selected. Further, of the students selected a large number are unable to register due to either financial constraints or not being able to obtain study leave from their employers, among many other reasons. Clearly, E-learning would provide a very useful approach towards addressing this problem provided access to computers with Internet connectivity is available.

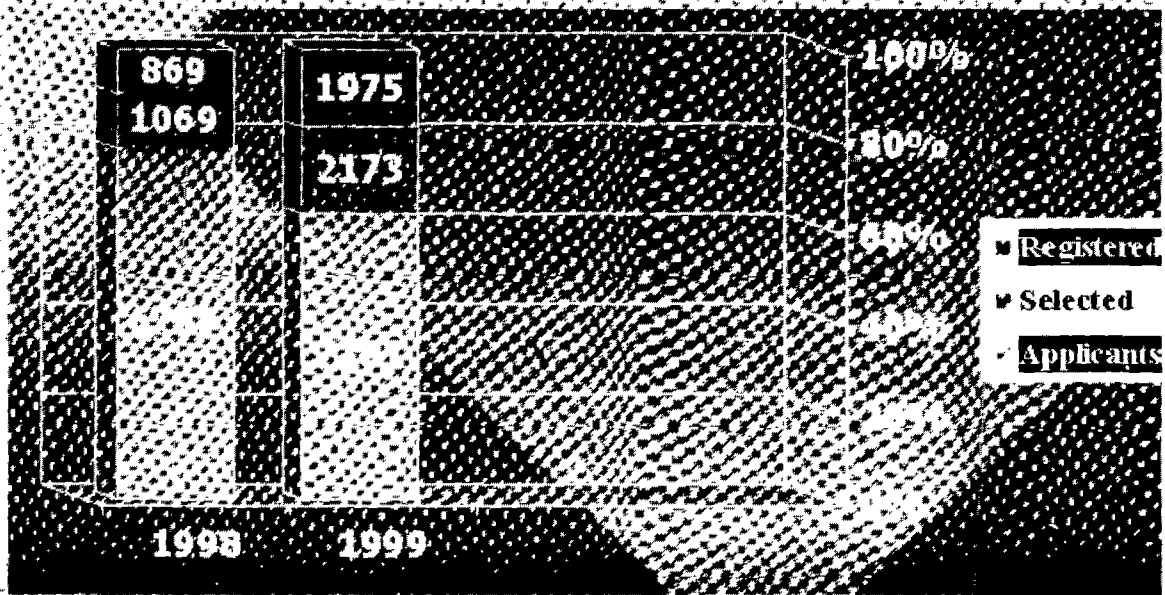


Figure 1. A comparison of the number of student applicants, selected and registered.

The school of engineering is working towards introducing a local E-learning programming in order to meet the huge demand for engineering education. However, how to conduct the laboratory exercises remains a great challenge.

One of the constraints that the University of Zambia faces in harnessing the full benefits of using ICTs effectively in Science and Engineering is inadequate infrastructure, such as PCs. For example at the Second Year in the School of Engineering the total number of students ranges between 86 and 110 with only 13 PCs to use. The solution has been to break down the class into smaller groups, which results in a laboratory exercise being repeated with the different groups over a longer period of time than would otherwise have been the case.

There exists a UNZA administered Project that aims at using Information and Communication Technology to increase the effectiveness of Community-based non-formal Education for Rural People (CERP) in Zambia. This is a partnership between the University of Zambia and the National Foundation for Educational Research (UK). The University of Zambia and the Department for International Development (UK) jointly sponsor it.

The CERP project is a Research and Development initiative to develop and test out new cost-effective educational strategies in non-formal education in rural communities. It is meant to build on existing Zambian initiatives and local expertise in non-formal education. The intention is to explore the potential of poorer rural communities to benefit from a wide range of technological educational tools. Unfortunately the CERP project has not yet yielded the expected results and this remains a major challenge for the university.

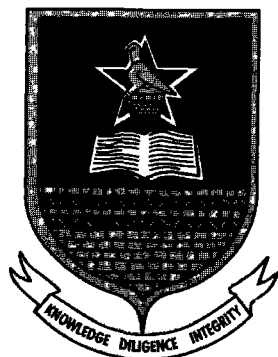
1 Suggestions

In order for the University of Zambia and other institutions of learning and research to effectively use ICTs in improving the relevance and quality of their activities the following could be done:

- Assessment of training and research needs in Zambia that can encompass ICTs. This should be followed by the identification of the key institutions that can organise and support training and research activities;
- There should exist information dissemination to target institutions and groups of people involved in ICT;
- Organising discussions and public talks on topics in ICT should also be encouraged as a means of arousing interest among the target groups;
- Developing of Institutional relationships and collaboration with institutions outside the country in areas of ICT; and
- Development of a clear understanding of the appropriate roles of ICT in science and engineering towards the developmental needs of the country.

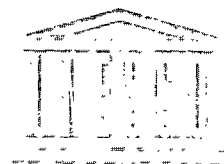
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USE OF ICT IN SCIENCE AND ENGINEERING
CASE OF UNIVERSITY OF
ZIMBABWE

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1 Current Status of the National ICT Policy

Zimbabwe does not have a national ICT policy. However, through a project funded by the UNDP, one is now being put in place (www.zarnet.ac.zw). A number of stages were followed in order to arrive at the policy, and these stages are outlined in the following sections.

1.1 Setting up a Policy implementation team

A representative team was put together. The team comprised persons from Commerce, Industry, Civic Organisations, and Government. There already was a K-Economy task force under the National Economic Consultative Forum (NECF). This was deemed the custodian for the formulation of the policy. Operationally however, a secretariat was set up under the Ministry of Science and Technology Development.

1.2 E-readiness Survey

An E-readiness survey was produced by the implementation team. This survey articulated the preparedness of the various sectors with respect to the use of ICTs. The extent to which ICTs were used by specific sectors was recorded. The survey looked at all areas of commerce, industry, and public affairs. Generically, for each area, the level of connectivity and the level of use of ICTs were covered.

The following areas were covered during the survey:

- a. Agriculture
- b. Commerce
- c. Industry
- d. Government
- e. Governance
- f. Education
- g. Health
- h. Youth
- i. Gender
- j. Mining
- k. Communication

1.3 Awareness Period

The awareness period was used to popularise ICTs and their use. It also made the public aware of the E-readiness survey. Additionally, the nation was to be made aware of the impending ICT policy compilation. The need for an ICT policy and the implications of lack of policy were also articulated. At the time of writing this report the awareness period was in progress.

A variety of communication media was used to reach "all" persons in the nation. The media used included, radio, television, print, mailing lists, and public lectures.

1.4 ICT Policy draft

Following the awareness period, a draft of the ICT policy would be produced. The draft will face the same level of scrutiny as the E-readiness survey. At the time of writing this report the first draft of the policy was being written, and it was due for presentation before the end of October 2005.

The understood aim of the policy is to produce an all encompassing document that will be used by persons developing ICTs and persons using ICTs. The document will give the general roadmap to be

followed by all stakeholders. It is going to be a time sensitive document. Aspects of the document will thus be reviewed periodically, say, every two years.

1.5 ICT Policy adoption

The ICT policy would be amended and adopted accordingly. It would serve as the instrument against which to measure ICT use, implementation, and development.

Lack of a national ICT policy has been a significant impediment to the general development of ICT in Zimbabwe. Some of the negative consequences of the lack of policy include

1. Haphazard establishment of corporate ICT policies.
2. Lack of a clear-cut structure through which ICT concessions and representation can be presented to the government.
3. Lack of a framework through which the nation can participate in regional and international ICT development efforts.
4. Lack of ICT related development. The nation does not have a purposeful effort to build ICT, whether software development or hardware components assembly, as a serious industrial and development area.
5. General lack of ICT direction

1.6 Impact on the University of Zimbabwe

The University of Zimbabwe is one of the institutions that would fashion its ICT policies and principles around an existing national ICT policy. However, absence of a national ICT policy has not deterred the institution. The University of Zimbabwe has proceeded to put in place an aggressive and forward looking ICT programme.

In some cases the participation of the University of Zimbabwe in regional and international forums has been hampered by the lack of a National ICT Policy. There are a number of instances where the university could not articulate how their programmes would serve the national needs.

2 Incorporating ICT in Science and Engineering in the National ICT policy

As stated earlier the National ICT policy is not yet in place. However, the indications as to whether ICT will be included in Science and Engineering Education are quite good.

1. **The e-readiness survey included e-Education and e-Industry:** It is thus the perceived intention of the national ICT policy to incorporate all fields of Education, thus including Science and Engineering. The inclusion of education was not en-block. The survey found it necessary to distinguish primary, secondary, and tertiary education separately. Science and technology aspects were also included in the survey of the industrial sector and its use of ICTs.
2. **The role of National University of Science and Technology (NUST) in producing the e-readiness survey:** The e-readiness survey was contracted to and produced by the National University of Science and Technology. One would therefore expect the university to have some influence on the end product. Additionally, the choice of NUST for this task is an indication of the confidence the government has in its Science and Engineering institutions with regard to the interpretation of ICT needs.

3. Involvement of ICT experts in the task force: The NECF K-economy task force includes three participants from universities and research institutes.

3 Incorporation of ICT in the Science and Engineering policy of the University of Zimbabwe

3.1 University strategic plan

The University of Zimbabwe uses ICT as part of its day to day operations, in teaching, research, and administration. The university strategic plan 2003 2007 proposes the use of ICT in all business, as major deliverable number 1. This is an indication of the level of commitment on the part of the university regarding the use of ICT. ICT in Science and Engineering is thus a by-product of this overall expected use.

In 2003 the University of Zimbabwe made a conscious policy statement regarding the teaching of ICT. Every undergraduate programme was required to have at least two ICT courses in its curriculum. For Science and Engineering the norm is typically more than two courses. Departments and faculties that were aggressive in implementing this policy were "rewarded and favoured" in the allocation of computing resources.

3.2 University ICT policy

The university put in place its first ICT policy in 1994. This policy articulated the ICT needs of the university relating to teaching, research and administration. It further elaborated on the implementation strategy and plan for the campus-wide computer network and related services.

The structure of the university network is such that there is more favourable capacity in the departments and faculties where the need for more bandwidth is greater. The original network had 100 mbps on the backbone and 10mbps to most of the department links. However, all the Science and Engineering departments had a 100mbps link. Figure 1 gives a schematic representation of the university network. Each "Fxy" point represents a faculty that is connected to F01 (the Computer Centre). Each faculty point has a direct connection of 100 mbps. At the time of writing this report the whole network is being upgraded to a 1gbps backbone with 100mbps connection to some of the departments. However, in a continued recognition of the increase in use of ICT resources by virtually all fields, most of the departments are going to be connected at 1gbps.

UZ Campus Wide Network Logical Topology - Final Version

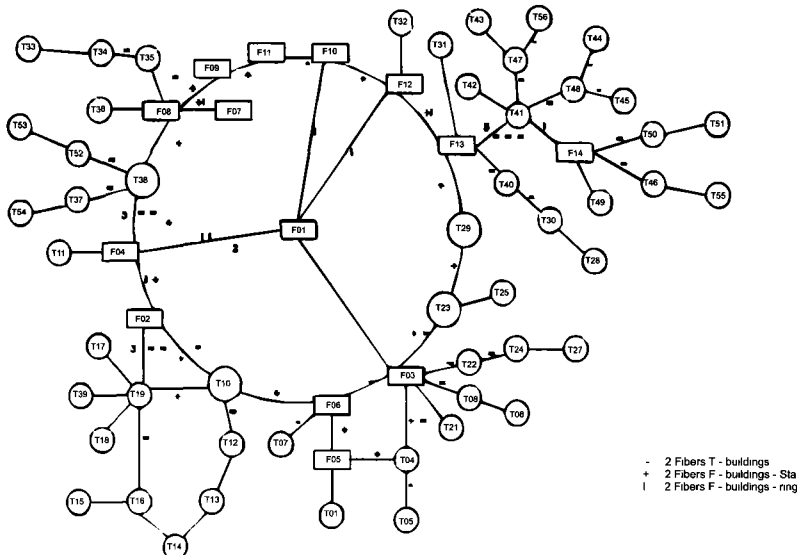


Figure 1: University of Zimbabwe Computer Network

In addition to the speed of the network there was immediate recognition of computing power in the Science and Engineering faculties. There was a deliberate policy of allocating powerful machines to these faculties. By so doing, the requisite computing power would be properly provided for.

Though there was equitable distribution of computing resources within the university, there was generally a bias towards the Science and Engineering faculties. One of the parameters used in allocating PCs and workstations was the number of courses in which a significant amount of ICT is required. These courses would be part of the officially established curriculum of a department.

1.1 University ICT Strategic plan

The ICT component of the overall university strategic plan was expanded on in the university ICT strategic plan. All monitoring and improvement of ICT issues was done through this plan.

One of the major result areas was the support to teaching and research through the provision of student and research laboratories. The plan charted a way to upgrade the backbone of the network, and thus increase the research capacity.

Teaching/Courses

Beginning in the year 2003 the university made it a requirement that all students graduating from the University of Zimbabwe would have graduated from at least two ICT classes. Faculties have thus been charged with ensuring that ICT courses are included in their programmes.

Curriculum change at the University of Zimbabwe is the preserve of the Senate. From 2003 a department proposing any change in curriculum has had to demonstrate that ICT is deliberately being incorporated.

1.2 Library

The libraries at the university have been aggressively automated. A library information management system was installed in the year 2000. This has improved access to material both locally and externally. A number of deliberate programmes have been put in place to further enhance the usability of the library for Science and Engineering, and indeed for all areas.

1.2.1 Provision of E-resources

The library, through international and local efforts, provides a number of electronic resources. These are in the form of e-Books and e-Journals. This is significant for all areas, but more so for Science and Engineering. Over the years the provision of books and journals in Science and Engineering had become significantly weakened. This was because of the prohibitive costs of these materials.

The e-Books are available in a variety of subjects. Most of these books can be downloaded by the user. This will make the books available locally on the desktop of the user. Where this is provided for, the scholar can even print out the book.

The e-Journals come in two forms, full-text and abstract. Both give the scholars valuable additional resources for learning and research.

The university continues to build its own local content repository. This comprises, among other things, the full text of theses that are awarded to all University of Zimbabwe graduates.

1.2.2 Digitising of Examination Resources

Provision of reading and research resources is one of the major preoccupations of the University of Zimbabwe libraries. In the past the library also collected all examination papers. For ease of access the library has digitised all "past" examination papers for access by students. Additionally, all current examination papers are now submitted in both print and digital format. The digital version is thus made available to scholars immediately upon completion of the scheduled examination.

1.3 Research

The university has addressed research needs by providing scientific laboratories. There are a number of laboratories equipped with ICT for use by post graduate students and researchers in general. The following is a list of some of the laboratories

1. **Computer Science laboratory for research:** This laboratory is equipped with Sun workstations. The workstations run Solaris. They have a number of software packages in accordance with the requirements of the researchers. The machines can be used as standalones or in a cluster.
1. **English laboratory for Multimedia:** The department of English has a post graduate diploma and a Masters programme in media studies. The students in these programmes use specialised equipment for Multimedia production.
2. **Faculty of Medicine Multimedia unit:** Within the faculty of Medicine there are a number of post graduate programmes. All of these programmes are supported in some ways by the multimedia production centre in the faculty.
3. **Agriculture Meteorology Laboratory:** The Physics department's Agricultural Meteorology unit houses a calibration laboratory. In this laboratory both portable and robust calibration instruments are available.
4. **Chemistry measurement laboratory:** The department of Chemistry in the Faculty of Science houses a state-of-the-art instrumentation and measurement laboratory.
5. **Veterinary multimedia centre:** The faculty of Veterinary Sciences has a multimedia laboratory. This laboratory is used by both research staff and students in the production of relevant research material.

4 Use of ICT in the classroom

The university has championed a number of efforts to ensure the use of ICT in classrooms. It is the general aim of the university to provide both teaching and learning computing facilities for use by students.

4.1 Campus wide and faculty laboratories

At the time of writing this report the university had an approximately 1:7 computer to student ratio. This is not desirable. The university has been striving to achieve a ratio of 1:4. This is the internationally accepted minimum computer to student ratio.

There is a total of about 2900 computers in the university. Of these about 1900 are intended for use by the students, but not all computers are meant for all students. In fact we currently are carrying out a study to determine more accurately, the actual usage and usability of the various computing resources that are available to students.

Table 1 gives a summary of some of the laboratories in the university that were provided from the central resources.

Faculty	Department	Number of Computers
Arts	Faculty wide	25
Agriculture	Faculty wide	25
Commerce	Faculty wide	50
Education	Faculty wide	25
Education	Human Resource and Research Institute	25
Engineering	Faculty wide	40
Engineering	Faculty wide	25
Law	Faculty wide	40
Medicine	Faculty wide	25
Science	Faculty wide	25
Science	Computer Science	150
Social Studies	Faculty wide	25
Veterinary Science	Faculty wide	25
Library	Main Library	75

Table 1: Student computer laboratories from computers distributed centrally

4.2 E-learning project

In 2003 the university embarked on an E-learning project (<http://uz.ac.zw/elearning>). The aims of the E-learning project were several including the following:

1. To make learning material accessible to students at all times
2. Generation of quality learning material
3. To be in line with international trends
4. To alleviate the continued strain on teaching and learning due to the shortage of reading material.

The E-learning project has implemented a Learning Management System (LMS) for all the courses that are offered at the University of Zimbabwe. There are four main levels of presence:

1. **Barest presence:** This is where the course is registered on the platform but has not been utilised. At the time of writing this paper, almost all academics were aware that their courses were at least present on the LMS.
2. **Basic presence:** The course has at least a course outline associated with it. Additionally, some resources and some of the forums are in use. The students are registered on such a course.

3. **Enhanced presence:** In this case the course has all the characteristics of 2 above. Additionally, the course material includes more than mere reference to external material. Assessment of students in this case is typically partially done through the platform. In addition, there is a learning path associated with the material on offer.
4. **Total presence:** The course material has been modelled to reflect good learning and delivery principles. Where necessary relevant multimedia methodologies have been used to build the course content.

A laboratory has been fully equipped for this function, and personnel have been trained and/or hired. These are helping to turn all courses into good E-learning enabled courses.

4.3 Examinations on line

In the last two years there has been an increasing use of computers in university examinations. Initially it was only short term courses that used computers to conduct examinations. Now the computer appreciation course in the Faculty of Education is being examined on line. This is a course that is taken by all students in the faculty.

4.4 Open Distance Electronic Learning (ODEL) project on University Teacher Education

The University of Zimbabwe is one of the ten universities participating in a project to bring E-learning elements into the teacher education programme. The project is called Open Distance Electronic Learning (ODEL). This program is sponsored by the African Development Bank, with the Africa Virtual University as the major facilitating agency. The objectives of the programme are twofold:

1. To increase the number of teachers trained through the programme.
2. To improve the quality of training in Teacher Education.

Through this programme the Faculty of Education department of Science and Maths education will be modernised using ICT. Courses in Maths, Biology, Chemistry, and Physics will be affected.

The investment in this project includes a fully furnished Multimedia laboratory, a delivery room, and Internet connection. University staff are being trained in the implementation of the programme. This is the first step towards making the content of a number of programmes available in the E-learning platform, for both local use and use by students in a distance education setting.

5 Use of ICT to popularise Science and Engineering

The University of Zimbabwe is engaged in a number of projects intended to popularise Science and Engineering. One of these is the computerisation of Groombridge Primary School.

5.1 The Groombridge Primary School Project

This project is intended to popularise Science at Groombridge Primary School, which is located at a distance of about two kilometres from the university campus. The university will undertake the following activities:

1. **Develop a School Management information system:** This management information system will be used for the efficient management of the administrative functions of the school.
2. **Training of all teachers and administrators:** Teachers and administrators at the

school have been trained and continue to be trained in basic ICT and first level maintenance of hardware and software computer systems. Training in basic issues is done by university students, and the more advanced courses are conducted by university staff.

3. **Development of traditional games using multimedia:** To preserve these, as well as add interest, Zimbabwean traditional games are being converted into usable units using multimedia. This will hopefully stimulate interest amongst the primary school children.
4. **Development of an ICT curriculum:** The project will finally develop an ICT curriculum for primary schools. It is hoped that the curriculum will be tested on the Groombridge primary school children. The curriculum will then be submitted to the Ministry of Education, to be adopted by all other primary schools in the country.

The donor agency will provide 50 computers to Groombridge primary school. On its part the school will furnish the laboratory and ensure that there is a maintenance budget for the up-keep of the equipment.

5.2 Project by students

Students at the University of Zimbabwe engage in a number of extracurricular activities. The university students recently participated in an international competition for the student and the community. In this project under SIFE (www.sife.org), students from the university chose to popularise community services through the use of ICTs. The project they presented was on teaching Small and Medium Scale business persons the correct principles of business. Additionally, they presented a number of agricultural projects.

In their presentation a number of multimedia principles were utilised. The university won the international prize for university community services. The SIFE project has generated a lot of interest, not only in community services, but also in the use of ICT in making presentations.

5.3 Student associations

Students' organisations play an active part in popularising Science and Engineering. Of note is the Computer Science department student's association (The Computer Science Students Association), and in the Electrical Engineering department (Association of Electrical Engineering Students). These promote both Science and Information and Communication technologies. Activities include:

- Presentations by professionals in the field
- Promotion of its members understanding of Science.

5.4 The Faculty of Engineering Student Projects Show

The Faculty of Engineering conducts an annual presentation of its best students projects to industry. Through this presentation industry and the rest of the university community get to know what the students are doing. This has generated interest both in what the students are doing, and in the engineering programme as a whole. Through this programme students have managed to network with industry, leading to prospects of future employment.

One by-product of this programme is that departments such as Computer Science and the Faculty of Agriculture will, with effect from 2005-2006 academic year, host their own presentations to industry.

6 ICT as a subject in the institution

The University of Zimbabwe is also promoting ICT as a subject in its own right. The university has,

through policy and implementation, promoted the Department of Computer Science and other related departments.

The department of Computer Science has two undergraduate programmes. These are a Bachelors Degree in Science, in the Faculty of Science, and a Bachelor of Business Studies and Computing Science in the Faculty of Commerce. These are the two entry level programmes in the department. First year student numbers have been increased from about fifty in 1997 to one hundred and fifty in 2005. The increase in recruitment numbers has been enabled by a significant increase in resources.

The two programmes offer "standard" Computing programmes. The syllabuses are adjusted in conjunction with prevailing international standards. Intake has been increased mainly due to a greater number of PCs in the department, up from 50 to the current level of 200.

The department of Computer Science offers a number of higher degree programmes. Initially, in 1997, the department introduced a fourth year honours programme. This was to cater for those students with potential, who had graduated with a bachelor's degree. It was also introduced to pave the way for the introduction of a master's programme.

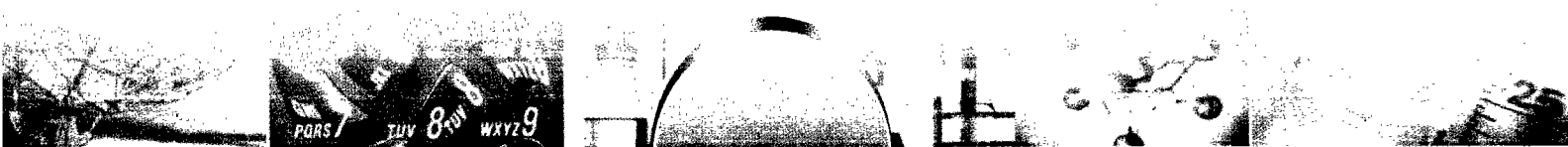
In 2001 the department introduced an in-stream honours degree programme. Under this programme students are identified after their first year of study for participation in an honours programme. The department recruits a significant number of students from this group for its master's programme. The number of students in this programme has been maintained at 15 students per year.

In the year 2003 the department introduced a Master of Science in Computer Science. At the time of writing, this programme had recruited its third group of students. The programme has support from both the university and external funders in Europe. This has managed to steady the programme as it is taking shape. The first three intakes in this programme have been of 12, 15, and 12 respectively. Already 10 students have graduated from the first intake.

Besides the Computer Science programme there are a number of other departments that are involved in ICT related teaching and research. These include Electrical Engineering which has a significant set of courses that are ICT related in its bachelor's degree. Additionally, there is a Masters Degree in Communication.

The department of Geo-Informatics and Surveying in the Faculty of Engineering has a bias towards Geographical Information Systems (GIS) in both its undergraduate and post graduate programmes. A number of other programmes also have GIS components; these include Geography and Environmental Sciences, Soil Sciences, Animal Science, and Biological Sciences.

As indicated earlier it is a requirement for all students in the University of Zimbabwe to take at least one ICT course before they complete their programme.



Intake	Level	Number Graduating
1	Certificate	74
2	Certificate	118
3	Certificate	119
4	Certificate	125
5	Certificate	130
1	Diploma	120
2	Diploma	140

Table 3: Number of students trained by Anstead School of Technology

7 Conclusion

The University of Zimbabwe has embarked on a comprehensive use of ICT in the delivery of teaching and research at the institution. It has deliberately placed emphasis on Science and Engineering Programmes.

8 Appendix

University of Zimbabwe Strategic Plan

2010-2015