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Effective Engineering Training: the Case of Kigali Institute of Science, Technology and Management*

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Current issues in regular curriculum reviews include the development of relevant programmes, self-sustainability due to the huge costs involved in setting and running an engineering institution, as well as close collaboration with the industrial sector; these all influence the effective training of engineering professionals. In Rwanda, which is a tiny country in Central Africa, engineering education was almost non-existent until after the genocide of 1994. The few skilled people who were present before the genocide were either killed or just disappeared. Training of all cadres of engineering: artisans, technicians and engineers were found to be inevitable thereafter. The issue remained to be the mode and the proportionality in the training of these personnel. This paper presents the case of Kigali Institute of Science, Technology and Management (KIST), Kigali, a higher learning institution that was established by the Government of Rwanda in November 1997 in order to respond to its crucial needs of high quality technical and professional workers. Over the four years of its existence, KIST has made an impact on the community and the country at large through its unique programmes in the region. The academic programmes at KIST are structured so that there is an output of skilled and competent technical workers at different levels every year. Despite these achievements, the Institute is still facing a number of challenges, which includes infrastructure development, modern facilities and locally trained staff

INTRODUCTION

Rwanda is one of the highly populated countries in the world with about 8.3 million people and a population density of more than 300 persons per square kilometre. With a population growth rate of 2.9%, the country's population is expected to double by around the year 2020. The country's economy is predominantly agriculture with 90% of the population living in rural areas owing their livelihoods to agriculture.

Rwanda remains one of the poorest countries in the world and poverty remains the greatest impediment among its people. Like most other sub-Saharan African countries, Rwanda has had a long history of a weak industrial base. During the post-independence years in particular, imports of finished goods and services, mainly from the North, were more to do with culture than appropriate technologies; this discouraged local capacity building and new initiatives. Over the years, this resulted in the country facing a multitude of challenges in its development and poverty reduction efforts.

The country lacks skilled personnel; there is a low level of technical training and little innovation in the fields of technology, communication, environment and economic development. Therefore, it becomes imperative to develop the country's industrial base from the present low levels by training technical personnel.

NATIONAL COMMITMENT AND EDUCATION POLICY

The National Education Policy highlights the areas of intervention among others: basic education for all and

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the emphasis on the quality and relevance of education at all levels in terms of skill provision and the development of science and technology.

Following a national survey to determine the training needs for technical and administrative personnel in the employment market, which was conducted by the Ministry of Commerce, Industry and Cooperatives, it was concluded that 90% of training requirements were for technicians and engineers [1].

Training needs were greatest in the fields of computer science, commerce and sales, management and the administration of personnel, leather industry, electro-mechanics as well as the popularisation of agriculture, chemistry, irrigation and the printing industry.

Another survey undertaken by the German Agency for Technical Co-operation (GTZ) and commissioned by the Ministry of Education on a sample of 25 small, medium and large businesses in the private and public sectors, indicated that the industrial sector needed about 2,145 engineer-technicians in 26 professions [2]. The most demanding areas included the hotel industry, construction, electricity, printing, mechanics, business and computer science, management and civil engineering.

The establishment of various higher learning institutions in the country after the war and genocide of 1990-1994, the rehabilitation and re-equipping of secondary technical schools and the continued campaign for industrial and technological innovation and development are all manifestations of the strong commitment of the Government of Rwanda to education.

ESTABLISHMENT AND ROLE OF THE KIGALI INSTITUTE OF SCIENCE, TECHNOLOGY AND MANAGEMENT (KIST)

The Kigali Institute of Science, Technology and Management (KIST), is the first technological institute of higher learning set by the government of Rwanda. Since its inception in 1997, KIST has been able to respond to the crucial need for high quality technical and professional workforce to support the development of Rwanda, which has been going through difficult years of economic decline and, later, war and genocide of 1990-1994. The skilled personnel were either killed or fled the country, leaving voids that have been difficult to fill. This tragedy increased considerably the number of vulnerable groups, such as orphans, the physically disabled, widows and the destitute. In addition, there was a massive return of refugees who had left the country in 1959 and 1973.

In 1997, KIST started with only three departments, namely: Engineering, Computer Science and Management. A language school to foster bilingualism and a centre for continuing education to administer part-time programmes were later established in 1998. To date, the academic structure at KIST has been expanded to include three full operational faculties: the Faculty of Technology, the Faculty of Science and the Faculty of Management.

The Faculty of Technology has six academic departments and two service departments. The academic departments are as follows:

- Electrical Engineering;
- Electronics and Communications Engineering;
- Mechanical Engineering;
- Civil Engineering and Environmental Technologies;
- Computer Engineering and Information Technology;
- Food Science and Technology.

The two service departments are:

- Workshop Technology, which is aimed at imparting hands-on skills to the students in various trades, such as electrical installation, welding, masonry, carpentry, etc.
- Cottage Industry, which facilitates entrepreneurships and small-scale business development.

PROGRAMMES AT KIST

KIST's unique programmes place strong emphasis on the practical-oriented curriculum in contrast to the theoretical or academic models. The full-time academic programmes in the Faculty of Technology have been designed to provide to students the need-based market sensitive skills at the levels of crafts-person, technician and engineers.

The structure of the academic programmes is demand driven in the sense that different levels of skilled technicians would annually be made available to the labour market as a short-term measure parallel to the training of engineers as medium- and long-term measures, since their programmes are relatively longer and more demanding. The number of students exiting at certificate and diploma levels would largely depend on the requirements and the performance of these students.

The Institute is implementing a continuing education programme that covers a variety of courses, such as computer applications, masonry, carpentry, electronics and telecommunication, radio and television repair, etc. These programmes are normally short courses

ranging between six months and one year. The main objective is to impart and update knowledge and increase efficiency of the working population from the private and public sectors. KIST derives its validity through the active role it has taken in training to fulfil its objective and provide an impact on the economy as soon as possible.

CURRICULUM

The first curriculum for the Faculty of Technology was developed so as to fulfil the first objective of producing highly qualified technical personnel, at both middle and high levels, as quickly as possible. This curriculum was developed based on the study conducted by GTZ and another study by the Department of Planning and Improvement of Higher Education in the Ministry of Education [3]. From the beginning, it was envisaged that the training at KIST must have the basic purpose of satisfying the existing and potential demand for the skilled workforce needed in the employment market. The curriculum for the full-time students was developed such that specialisation in core courses would lead to either a certificate, diploma or degree award at the end of each successive year of the four- or five-year programme.

During the implementation of the initial objectives, a new curriculum was required in order to fulfil the long-term objectives of KIST and focus on future job market needs for technicians and engineers. The Education Consultancy group of India (EdCIL) was commissioned by the African Development Bank (ADB) in 2001, on the behalf of the Government, to study the labour market in Rwanda and consequently advise on academic programmes. The outcome of the study was a parallel academic curriculum whereby various diploma and degrees are offered after 3 and 4 years respectively, and pursued in different channels. This was in opposition to the initial series curriculum that had already been in existence for four years [4].

INSTITUTE-INDUSTRY PARTNERSHIPS

KIST has the responsibility of establishing strong links with the private sector and civil society, particularly with regard to important developmental matters of innovation, competitiveness and the creation of business opportunities.

It is within this context, as obtained in the mainstream of curriculum, that students are required to undertake programmes in community attachment for four weeks and industrial attachment for eight weeks. These programmes take place at the end of the second year and third year respectively, and are intended to expose students to real work situations where knowledge is integrated with skills and the necessary tools to attend to social needs.

At the end of the programme, each student is expected to submit a comprehensive technical report, which is presented for discussion together with other students and a panel of academic staff to evaluate the work. The occasion forms an important forum where students share different experiences and where academic staff members get the opportunity to assess the effectiveness of each case. The industrial training component also gives employers a chance to evaluate the performance of KIST students at different levels. Their recommendations and reactions are always considered during curriculum review.

Under the area of skills development and the updating of knowledge for KIST staff, there is a strong level of collaboration with industries whereby most of KIST's staff are seconded for professional training in various industries. At the same time, staff from industries, ministries, private sectors, etc, are encouraged to conduct part-time teaching at the Institute. Some KIST staff members have become regular members of the management boards of the public and private sectors. Furthermore, seminars, conferences and public lectures are regularly organised at KIST in order to strengthen partnerships with these sectors.

There is extensive collaboration between KIST and the industrial sector, which has proven useful for the development of the Institute. Further collaboration is found in consultancy services, student sponsorship and joint ventures. It is envisaged that future partnerships will be in research sponsorship, professorial chairs, donations and gifts, student prizes and the planned Centre for Development Studies. The KIST statute requires that representatives from the private sector be involved with the Governing Council of the Institute.

INCOME GENERATION ACTIVITIES

In addition to the academic programmes available to both full-time and part-time students, KIST is also keen to reach out and assist industrialists and entrepreneurs with different needs. The production department, the unit responsible for the outreach programmes, is placing extra emphasis on locally developed technology.

The construction of bio-gas and bio-latrines plants for Rwandan prisons, schools and hospitals, efficient community cooking stoves, efficient bread making oven machines, etc, have all impacted positively on the community for their simplistic and easily adaptable technology. Moreover, they have also enabled the Institute to raise funds for its sustainability.

Fee-paying students, consultancy services and Internet service provision are other aspects of income generating activities at KIST, to mention but a few. The revenue generated is used to support applied research and development activities, as well as in meeting other expenses, such as infrastructure development, laboratory equipment, recurrent expenses, etc.

APPROPRIATE TECHNOLOGY AND INNOVATION

KIST continues to impart Rwandan society with the high skills of innovation as exemplified by different and appropriate technologies. The knowledge is disseminated through training, consultancy, service to the community and applied research. An impressive pace has been taken in technology as it relates to: information and communication technology, biogas and bio-latrine plants, sanitation improvements, energy saving cooking stoves, rainwater harvesting, solar energy technology and technology for cottage industries.

The emphasis on these technologies is on the transfer of technology through the installation of units for the community while also providing training as an income-generating project for the self-sustainability of the Institute. The extent of KIST's achievements in technology transfer is summarised in Tables 1-3.

In addition to the significant impact that has been made by some of these technologies in their places of need, their introduction and display at KIST has played an educative role to both the community and the visiting public.

In particular, engineering students are referred to the units at relevant topics of class lectures. Visual observations are also encouraged where applicable. In addition to that, some students specialise their projects in these technologies, resulting in the acquisition of useful skills in various aspects of planning, designing, construction and installation.

Table 1: KIST's achievements in biomass-based technologies.

Technology	Installation	Training
Bio-gas plants	10 households units and 12 institution units installed	10 technicians and 15 prisoners trained
Improved cook stoves	500 institutional units installed	20 entrepreneurs trained
Improved bread ovens	60 units in operation	4 youths trained
Briquetting technology	Joint research	1 entrepreneur trained

Table 2: KIST's achievements in solar energy-based technologies.

Technology	Installation	Training
Solar water heating system	14 units installed and operational	4 technicians undergoing on-the-job-training
Crop solar drying system	Undergoing performance tests	4 technicians undergoing on-the-job-training
Solar electricity	8 units installed	2 weeks course conducted

Table 3: KIST's achievements in other technologies.

Technology	Installation	Training
Improved kerosene stoves	100 units installed in house holds	8 youths trained
Instant showers	10 units produced (4 units in use)	-
Water pumps	Prototype	-
Rainwater harvesting	2 systems operational	-
Rural transportation -oxcarts, push carts, wooden scooters	10 units produced & in use	-
Rural transport infrastructure	Suspended pedestrian bridge connecting two provinces	4 KIST students trained
Food processing unit: jam, juice, tomato ketchup	Unit operational at KIST	20 women trained

CURRENT STATUS

KIST has now devised a development plan, the KIST *Strategic Plan 2001-2006*, to guide the Institute's developments in the short-term [5]. The rolling plan, to be reviewed annually, has 32 objectives for the realisation of its goals, mainly: the adoption of higher education norms and the demonstration of relevance and viability to assure public support and funding. There is a weekly follow-up on the implementation of the actions stipulated in the plan for the attainment of each goal.

Now four years later, the country at large has begun to feel the impact of the programmes that are being offered at KIST. There are clear indicators of quality training being offered.

Over the span of the four years of its existence, the following have been achieved:

- Solid programmes (full-time, part-time, short-term, customer-based, distant learning) have been designed and are subsequently running on schedule, while also observing Quality Assurance (QA).
- Administrative and academic structures are in place.
- There is substantial growth in the number of students and qualified staff. The number of students has increased from 209 in 1997 to 2,196 on a full-time basis and 1,456 on a part-time basis to date.
- A cottage industry unit has been established with the objective of training and empowering as many disadvantaged people as possible with the necessary entrepreneurships skills so that they can develop viable businesses and consequently increase opportunities to improve their quality of life.
- A production unit, which is responsible for all income-generating manufactured items, is operational. The unit also has the added responsibility of training personnel for the purposes of technological transfer.
- The Information and Communication Technology Service Centre provides practical training and demonstration to those students who are studying computers and information technology. It is through this Centre that KIST also provides Internet services to the public.
- Self-help measures for sustainability that include fee paying students, consultancy services and commercialised activities.
- Cooperation with the private sector through their representation on the Council, the sponsorship of students by the private sector, industrial attachments, joint ventures, public seminars and lectures.
- Cooperation with several international academic institutions nationally and abroad. Cooperation mainly focuses on the exchange of faculty and students, research and publications, as well as joint programmes and projects.

Future plans of KIST include the following:

- The establishment of a centre that focuses on innovation and technology transfer. This centre will develop relevant technological innovations and ensure sustainable transfer and adaptability to the people who need them the most.
- The establishment of a technology park to assist entrepreneurs in the development of technology-based business.
- The conclusion of the joint venture with Rwandacell, the country's sole mobile phone operator, to expand the current services provided with regard to information and communication technology.
- The provision of cost-effective delivery of programmes.
- Implementation of KIST's Strategic Plan.
- The establishment of a centre that offers consultancy services [5].

Together with all of these successes in producing skilled personnel in different levels of engineering field, KIST realises that there is still a long way to go. The challenges that are currently facing the Institute include the following:

- Shortage of laboratory equipment in the Faculty of Technology.
- Payment of salaries for expatriate staff.
- Insufficient reading materials in the Institute's Library.
- The inability to send local staff abroad for post-graduate studies in order to replace expatriate staff.
- Sufficient computers for students so as to meet acceptable standards.
- Complete a new building to house laboratories, classrooms, etc, for the rapidly increasing number of students.

CONCLUSION

Engineering training is an expensive venture in any setting. The commitment and full involvement of all stakeholders and actors in the delivery of engineering education and the absorption of graduate technicians and engineers into the market is a crucial undertaking in order to enhance engineering education, especially for developing countries. Current debate in engineering education in Rwanda must therefore become expanded beyond what it is now.

The issues of quality and quantity need serious consideration. Higher enrolments must be achieved, but enrolments by themselves are not enough. Staff development programmes, curriculum reform, research and publications, hands-on instruction through the use of laboratories and other practical methods must be brought into the engineering educational reform

agenda. These are factors that have a direct impact on whether or not KIST can meet the national development objective of improving the political, social and economic conditions of the Rwandan people.

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BIOGRAPHIES

Prof. Silas Lwakabamba graduated with BSc (1971) and PhD (1975) in mechanical engineering from the University of Leeds, UK. He then joined the Faculty of Engineering at the University of Dar-es-Salaam, Tanzania, and progressed to the rank of Professor in 1981.

From 1985-1997, he was the Founding Director of Training and Extension Services at the UN-sponsored African Regional Centre for Engineering Design and Manufacturing (ARCEDEM) in Nigeria. Prof. Lwakabamba is currently the Founding Rector of the Kigali Institute of Science, Technology and Management (KIST), Kigalia, Rwanda, since 1997.

At the international level, Prof. Lwakabamba is a member of the Executive Board of UNESCO, a member of the Executive Board of the African Virtual University (AVU), a member of the African Technical Advisory Committee (ATAC) of the UN Economic Commission for Africa on the development of ICT in Africa and Fellow of the World Innovation Foundation based in the UK. In February 2003, he was awarded the UICEE's Silver Badge of Honour at the *6th UICEE Annual Conference on Engineering Education.*

At a national level, Prof. Lwakabamba is the President of the Institution of Engineers of Rwanda and the Chairman of the Board of Director of the Parastatal Telephone Company (RwandaTel). He is also a member of various national commissions and steering committees on economic affairs, information and communication technology, human resources development and higher education.

He has over 30 publications in the areas of combustion, higher education, science and technology, energy and power production.

Dr Nelson K. Lujara received his BSc (Eng) (1987), MEng (1990) and DEng (1999), all in electrical and electronic engineering, from the University of Dar-es-Salaam, Tanzania, McGill University in Canada, and Rand Afirkaans University in South Africa, respectively. He is a senior lecturer and Dean of the Faculty of Technology at the Kigali Institute of Science Technology and Management (KIST), Rwanda, since January 2000.

Until February 2002, Dr Lujara was a also a senior lecturer in the Department of Electrical Engineering of the University of Dar-es-Salaam. His research interests are in the areas of engineering education, renewable energy and power electronics.