Strategic Issues in Engineering Education in Africa

Report of the Expert Group Meeting on Engineering Education in Africa

NAIROBI KENYA

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The consultants and participants in the meeting are responsible for the views and recommendations contained in this report which do not necessarily represent those of UNESCO and do not commit the Organisation.
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In pursuing UNESCO’s objective to improve, update and strengthen university teaching in the basic and engineering sciences, particularly at the undergraduate level, the Nairobi Office of the organization, relying on the existing networks such as the African Network of Scientific and Technological institutions (ANSTI) embarked on several activities in the African region. These included the preparation of learning materials in engineering science as well as the examination of the key issues in engineering teaching. The latter was necessary in order to provide advisory services to member states in updating and re-orienting their university curricula to keep abreast with the rapidly changing technological scene as well as the demands of the society.

Thus, in November 1995, the UNESCO Nairobi Office convened a meeting of nineteen (19) African experts involved in the planning, development and implementation of Engineering Education programmes. They deliberated on the problems facing engineering education in Africa and identified several strategic issues which are important for the improvement of quality and equity in the training of engineers. This report summarizes the proceedings of the two-day meeting. It discusses the various problems facing engineering education and raises many issues that have to be resolved. It further presents several recommendations, made by the experts, on ways of resolving the various issues identified.

The expert group meeting and this report are the first two steps in a series that is intended to facilitate the revision and upgrading of engineering education in Africa. It is hoped that the recommendations contained in this report will enable institutions, governments and international organisations involved with Higher education in Africa to formulate projects and programmes that will strengthen engineering education in Africa.

UNESCO, is grateful to the authors of the working documents and all the other participants for their valuable inputs during the meeting.

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Summary

This report covers the deliberations of the Expert Group Meeting on Engineering Education in Africa, which was held at the UNESCO Nairobi Office, Kenya from 1-2 November 1995. It discusses the major problems facing engineering education and highlights some of constraints and presents recommendations for overcoming them. In particular the report makes recommendations on important factors such as finance, university-industry collaboration, student creativity, innovation in the delivery and administration of engineering education, training for self-employment, staff development and the amelioration of the brain-drain.
It is now a well established fact that the wealth of a nation depends on the quality of its human resources. Indeed there are several third world countries which possess large amounts of mineral and other natural resources but continue to remain poor because of the lack of skilled human resource. On the other hand many countries which are not endowed with natural resources are today very wealthy because of the quality and quantity of their skilled manpower.

The economic development of any country rests heavily on human effort. Skilled and well trained men and women are needed to discover and exploit natural resources. They are required to mobilize the capital, develop the technology, manufacture and distribute the products and provide services for the benefit of society. No nation is likely to develop if it lacks adequate scientific and technical manpower. Thus, engineers and the process by which they are educated and trained are important to the economy of a nation. This is why periodic examination of issues involved in engineering education is very important for national development. Such examination enables those involved with engineering education to provide the training that will be useful to society.

Engineers are required regardless of the direction in which the national economy is moving. When it is in depression, engineers are required to invigorate it through creativity and innovative approaches to problem solving. When the economy is buoyant, engineers are required to keep it afloat through proper industrial management, maintenance and productivity enhancement techniques. So, the question is not whether a society should produce engineers but rather what type of engineers are required at a particular point in time.

Engineering education in Africa is going through trying times. Standards and quality are falling as the resources needed continue to
decline. There is a decline both in the quality of student intake and the facilities that are required to make them good engineers. Over the years there have been several innovative approaches to the solution of the problem. Innovative teaching aids, capacity building through international collaboration, restructuring of curriculum and alterations in course duration are just, some of what have been employed to combat a problem which seems to be growing every year.

The biggest problem facing higher education in general and engineering education in particular, is the lack of adequate financial resources. Over the last decade, as the economies of African countries have declined so have the resources available to higher Education Institutions. And the increase in population now means that there are less resources for more students. Engineering schools have a special responsibility in this difficult situation. They must develop programs and curricula that enables the local industries to be productive enough for the economies to grow. In other words, engineering education must be adapted not just to cope with the economic problems rather it must aim at solving them. Creativity and entrepreneurship are just two of the qualities which Africa's engineers desperately need and engineering programs must take note of this.

Even without the economic pressure and the consequent changes in societal needs, engineering education need periodic overhaul because the profession is very dynamic. It changes not only in response to societal needs but also as a result of advances in science. Recent advances in biotechnology, computer applications, material science and other scientific discipline would clearly have influence on the future of engineering curriculum and the delivery of engineering education.

Thus, as we approach the 21st century we need to begin to identify those issues that are strategic to the future of engineering education in Africa. To do so we must raise and answer two basic questions. What are the constraints facing
engineering education in Africa and how can we overcome them? What role can engineers, and for that matter the engineering schools, play in changing the economic fortunes of Africa. The answers to these questions raise many issues which is what the expert group meeting was expected to discuss.

One of the objectives of UNESCO’s Programme for cooperation in the basic and engineering sciences is to improve, update and strengthen university teaching in the basic and engineering sciences particularly at the undergraduate level. Through regional and sub-regional meetings the key issues in engineering teaching are examined so as to provide advisory services to member states in updating and re-orienting their university engineering curricula to keep abreast with the rapidly changing technological scene and to enhance the uses of environmentally sound technologies.

The expert group meeting on strategic issues in engineering education in Africa was held to fulfill the above-mentioned objectives of UNESCO. The meeting was expected to undertake an assessment of the issues involved in engineering education in Africa with a view of making specific recommendations on changes in engineering curricula and other extra curricula factors that affect the engineering programs.

More specifically, the objectives of the meeting were as follows:

(i) to identify all the issues that emerge from the way the different factors affect engineering education in Africa.

(ii) to discuss and make recommendations on how to overcome constraints associated with the issues identified.

(iii) to suggest activities, projects, linkages and cooperative programs that should be introduced into engineering education programmes in order to improve on their qualities.
The meeting examined three types of factors that influence the nature of engineering education. The examination of these factors led to the identification of constraints and hence raised several strategic issues for discussion and consideration by those involved in engineering education in Africa.

There were three groups of factors considered as important in defining the nature of engineering education. In the first group were those factors that define the problems that the engineering graduates would have to tackle. The factors in this first category included the needs of the society, the needs of local industries and the professional requirements. The discussion of such factors led to issues such as employment of graduates and equity in access to engineering education.

The other set of factors that were considered dealt with the technique for knowledge delivery. The factors discussed included the engineering programs, the resources available within the institutions, the nature and the effect of donor assistance and technical aid, and innovations in teaching and learning techniques. The discussion of these factors raised many issues among which were the issue of duration of courses, curriculum design, financing of engineering schools and innovations in teaching.

The third and final group of factors which were discussed at the meeting relate to evaluation and regional and international accreditation. The meeting discussed the role of external examiners, the University-Industry committees and the National Engineering Advisory boards. The main strategic issues involved here, were, the methods and objectives of the assessments of engineering education.

In general the discussions covered the basic weaknesses and constraints encountered in the engineering education system in Africa. And the recommendations were on the ways of overcoming the constraints.
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1.4 Participants

There were eighteen (18) participants from all regions of Sub-saharan Africa. They were mostly deans and former deans of faculties of engineering in African universities, heads of department in engineering schools, representatives of agencies which usually give support to higher education in Africa and female engineering lecturers. The participants together had a lot of experience on the problems and opportunities in engineering education in Africa. A list of participants is given in the Appendix.

1.5 Meeting Format

A few months before the meeting, the UNESCO Regional Office in Nairobi, commissioned the preparation of four (4) papers on important issues in engineering education. Participants at the meeting also submitted country papers on topical issues in engineering education in their respective countries. There were also some journal articles which were circulated to participants for background reading. The three (3) types of papers (i.e. the commissioned papers, the country papers and the background reading materials) constituted the working documents. A list of papers discussed at the meeting is given in the Appendix.

The working documents were used to provide discussion and bring out issues to be deliberated upon. The first few sessions of the meeting were devoted to presentation of the papers. During the presentations several issues were noted. In the final three sessions of the meeting each of the issues identified was discussed separately and some recommendations made about it.
The UNESCO Office in Nairobi commissioned three papers which examined different aspects of Engineering Education. Two of the papers dealt with access to Engineering Education with particular emphasis on gender equity. These were (i) Gender and other Equity Issues in Access to Engineering Education in Africa by Dr. M.R. Halfani; (ii) A survey of Present status and Trends in the Training of women Engineers in Africa - A case Study of Nigeria by Mrs. A.O. Ogunbayo.

The third commissioned paper examined the current trends in engineering education in Africa. The authors carried out a small survey of the situation in several engineering schools in Africa. The paper was prepared by Prof. EM. Luti and Dr. A.V. Otieno and is entitled Strategic Issues in Engineering Education in Africa.

The presentation of the papers and the discussions that ensued highlighted many of the problems encountered by engineering schools. These included the inadequacy of financial resources, unprogressive management structure of universities, staff problems, quality of enrollments, relevance of the curriculum, lack of cooperation with local industry and the society's perception of the engineer. The history of the development of Engineering Education which explains some of the problems, was also presented. In this chapter we highlight some constraints which confront engineering education including those with origins in its historical development.

Most of the major African faculties of Engineering were founded by former colonial governments or through foreign, mostly European, donations of both material and manpower. The curricula and the engineering education system were modeled after foreign institutions. During the few decades since the establishment of these institutions, there has not been restructuring or alteration in any of the systems originally put in place. As a result there has been a deterioration in the structures and the quality of the education provided. Some
institutions continue to rely on teaching techniques, syllabi and other aspects of engineering education which has already been abandoned in other parts of the world.

It is interesting to note that although the foreign institutions (i.e. the god-parents of the African Engineering Schools) have undergone and continue to undergo tremendous changes in curricula in response to the evolving requirements within their technological and socio-economic environments, the African counterparts have hardly started to address themselves to the need for changes. Yet they must change and re-orient their programmes if they are to adequately serve the needs of their society. In many ways the historical development of the engineering institutions in Africa had also imposed some constraints on its ability to respond to its socio-economic environment and the associated technological manpower needs. In the first case, there is the pre-occupation with recognition of degrees by foreign institutes. There may not be anything wrong with this. On the contrary it is desirable. However it is easy to see that an institution which constantly aspires to satisfying the requirements of foreign institutions (which are based on the latter’s own societal needs) will find it difficult to respond to needs of its own society without over-burdening the programmes. Another constraint is that on collaboration among institutions even within the same country or sub-region. Most institutions prefer to maintain links with European Institutions. While this is very desirable, it should not be at the expense of the regional Inter-institutional collaboration. The latter can be very useful for the sharing of experiences with problems peculiar to the sub-region especially in the field of civil and environmental engineering.

The challenges of training an engineer in Africa are extremely severe. The government provides funds for most of the training activities. Thus, as the national economies weaken the resources at the disposal of the engineering institution also decline. Over the last decade the funding level for tertiary education in most African countries has at best been stagnant. As a result the
equipment in place is either that which was acquired originally when the faculty was established or donated later through some form of bilateral or multi-lateral technical assistance. Some of the newer faculties even lack basic laboratory equipment and students have to be bussed to share obsolete equipment in the older universities. The use of modern teaching aids is however becoming popular. In particular it is gratifying to note that computer aided learning (with interactive software) facilities exist in most universities. About 40% of institutions have introduced Computer Aided Design while 10% use computer simulation, in lieu of non-existent laboratory equipment, for measurements. The availability of textbooks and a well equipped library is also another major constraint facing engineering education in Africa. While there are several textbooks in all subjects available on the world market, their prices have become a problem for most students due to the continuous devaluation of the local currencies. For a similar reason universities are also unable to stock libraries with current editions of textbooks.

2.3 Management of Universities

In all African countries the government is a major stake holder in university education. It funds the universities and therefore in essence runs them. This can be a constraint if government interference stifles innovation in university administration. Appointment of the managers of universities directly by governments or by proxy, has the potential to discourage initiative within the rank and file of the academic staff who may feel left out of the system. In most cases these senior political appointees’ priorities may have to do with policies external to the institution and personal survival rather than the academic well being of the university. A major strife in the region concerns the democratization of universities and granting them independence in the appointment of senior managers. Such an arrangement will encourage incumbents to look to the university as their constituency and will pay less attention to national politics.
2.4 Availability of Staff

There are three aspects to this problem. In the first case, the number of staff at post is usually very small. Secondly the qualification and experience of several of the lecturers at post are low. There is a large number of lecturers with only a Masters degree and one or two years experience. In fact only about 50% of staff have Ph.D. The third staff problem is the lack of dedication especially from senior members of the academic community. The inordinately poor remuneration for university staff make it extremely difficult for them to dedicate themselves to academic duties. Most of their time is spent on trying to earn extra money through consultancy and part-time work. Little time is allocated to academic work.

Some universities have staff development programme which is aimed at improving the qualification as well as the number of staff. Unfortunately this has turned out to be a disaster in most cases as staff members go away and fail to return.

The staff problem is at two levels: The level of the academic members and also at the technician level. The shortage of qualified technician has affected the laboratory infrastructure. Several equipment lie idle because of lack of qualified staff to undertake repair and maintenance.

2.5 Enrollment

Since there has not been much expansion in the facilities in Engineering institution, the enrollment now exceeds the resources available. In almost all cases there are high course loadings with thirty five (35) contact hours or more per week. (Luti and Othieno; 1995). Eighty per cent (80%) of the institutions surveyed claimed that student laboratory groups are too large. The enrollment of women is however very small averaging around 4% of the total engineering student population.

The problem of enrollment is viewed in two different ways. One point of view is that the level of enrollment is already very high and it is
blamed for the high level of unemployment among engineering graduates and the overcrowding in the laboratories. Another point of view is that the enrollment is very low and it is the facilities that should be expanded to cope with the demand for engineering education. Those who share this view, refer to the fact that African countries produce only about 10-20 engineers annually per one million people while some industrialized countries produce 200-300 engineers annually per one million people (Halfani; 1995). Furthermore, it is obvious that the number of engineers and scientists has to increase substantially for any meaningful scientific and technological development to take place. There is a critical level of scientific manpower below which it becomes difficult for the application of Science and Technology in development.

Since the enrollment already exceeds the carrying capacity of the facilities available, the engineering institutions experience an excess of demand over supply for places. For instance in the university of Dares Salaam only about 70% of the qualified applicants are enrolled. There is therefore need for expansion of engineering schools if the objective is to reach a critical level of technical manpower on the continent.

The survey by Luti and Otieno revealed that most, if not all, traditional disciplines of engineering are offered in various African universities. Most awarded either a B.Sc. or B.Eng. degree after courses that lasted 4-5 years. Total pre-university education ranged from 12-14 years. The relevance of some of the curricula to the development needs is questionable. In some universities, the curriculum has not changed very much since the establishment of the programmes. There is need to re-orient the engineering programmes so as to make the graduates “self-employers” and entrepreneurs in order to overcome the problem of unemployment. The problem of maintenance management is another issue that need to be addressed in curriculum design.
The revision of engineering curriculum in African universities is currently constrained by two factors. One is the non-availability of senior academics who should be central players in engineering curriculum development. This is directly linked to the staff problems discussed earlier. The other factor is the university bureaucracy. In many institutions, the procedure for introducing new curricula is very time consuming. Even a simple syllabus revision can take years to be approved by the university senate or the relevant academic board.

Industries are major partners in the training of engineers. They are required for the practical training aspects of the engineers. As consumers of the products of universities, they should also be involved in the design of curricula.

The role and importance of industrial attachment of undergraduate students as part of training in engineering is recognized by all institutions. Most of them have formalized industrial attachment programmes which are sponsored either by government or jointly by government and industry. Most institutions also treat industrial attachment as part of the curriculum and some even assess the attachment.

Only a small number of institutions consult industry in curriculum design. Most consult only national professional institutions which may be an indirect way of seeking the advice of industry.

A very important aspect bearing adversely on engineering education, has been the region’s scientific and technological culture which can be described as nascent at best. Society at large has not come to appreciate that science and technology is the driver of development. As client, financier and consumer of university products, they could play a catalytic role in stimulating facilities to make curricula relevant. There is even a common vein of belief that engineers are not good at decision making as
these should be left to social scientists and politicians. Furthermore, there is a common misconception that once through the university, the engineer knows everything, resulting in a culture which does not favour continuing education and internship.

These misconceptions adversely affect the fortunes of engineering graduates. It leads to unemployment or underemployment of the graduates.
During the discussion of the current state of engineering education in Africa, several issues emerged from the constraints identified. These included duration of engineering training programmes, curricula design, innovations in engineering education, international collaboration, trends in evaluation/assessment, development of creativity, access to engineering education, training for self-employment, university-industry cooperation, financing of engineering institutions, the brain-drain, and planning strategies/mission statements. Some of the above issues overlap. In this chapter we present highlights of the discussion on these issues. In the subsequent chapter specific recommendations on each of these issues will be presented.

The biggest constraint facing engineering education is the lack of finance. At issue is how to generate additional funds to run engineering programmes. Current levels of tuition paid by students are inadequate and most governments, for political reasons, are usually unwilling to increase tuition. Thus, engineering education, which is more expensive than social science and liberal arts education should look for alternative means of funding. Three major sources of funds were discussed. The first one was income generation from consultancies /research contracts. However, it was felt that consultancies and fee paying activities involving staff should be reserved for the purpose of motivation, although some of the fees could go towards maintenance of equipment. The other possible source of income discussed was “cost recovery” charges to students for the use of certain laboratory facilities. This could in fact turn out to be a subtle way of increasing tuition fees. Engineering faculties can decide to transfer some or all of the cost for the use of laboratory facilities. The third option discussed was the imposition of a training levy on industries. For the purpose of this levy there were two types of industries: Those which employ the graduates from local
institutions and those which employ foreign engineers. It was felt that while all industries should be subjected to the training levy those which employ foreign engineers, should be taxed more on the grounds that they needed to strengthen the local training institutions in order to reduce the dependence on foreign engineers.

The problem about training levies is the collection and disbursement as well as the fear of overburdening the local industries with taxes. Some governments may collect the levies and use it for other programmes. In order to overcome this, it was suggested that, perhaps the training levy should be charged per engineer employed by a particular industry and this should be paid annually by the industry to a professional society as part of the professional engineers registration process. The professional society will then transfer the funds to the faculties of engineering. A law or statute will be required for this to take place.

When the financial problem results in scarcity of physical resources, one means of circumventing it is to introduce shift system for use of the scarce equipment.

The overall strategic issue is how do we make engineering education relevant and useful to industry which employs the products. The issue arises from the knowledge that industry can play a major part in the training of engineers by providing opportunities for practical training both during and after the degree programme. One of the basic weaknesses of engineering qualifications at the present time is inadequate practical training. Industry can also participate in the design of curricula that are more relevant to their needs.

Various areas of cooperation were discussed. These included: cooperation in curriculum design, industry-based practical training of students and the use of part-time lecturers from industry. The mechanism and financing of the collaboration were some of the tactical issues discussed in relation to university-industry cooperation. The problem of financing
university-industry cooperation particularly industrial training of students could be handled in a manner similar to that proposed for the general support of engineering education. Either government should pay for it as part of its subvention to the universities or levy a training tax in industries.

In general, university-industry cooperation in most countries is likely to be very difficult even with the greatest will. This is due primarily to the weak industrial base. The manufacturing sector is dominated by small scale industries and the informal sector. A useful thing to do would therefore be for universities to find out what they can do for the small-scale sector by way of improvement in productivity, design and quality control. Small scale industries normally do not see the need to employ engineers because they cannot fathom the improvement it would bring to their profit margin. Therefore a demonstration of the benefits of the engineer could instill enough confidence for them to hire one.

The main issue in this case is defined by the shortage of staff at all levels to deliver engineering education. The staff development programmes have not been successful in most cases as staff who are sent for training either do not return to the country or when they do, they go to private enterprises. There are several reasons for this external and internal brain drain. One very obvious one is the low remuneration offered in national institutions and the other equally important reason is the poor infrastructure which is not conducive to academic activity.

The tactical issues involved in staff development would include the search for ways of improving the income of staff. The distribution of consultancy fees provided for work within the university must be done in such away as to allow the staff member to retain a significant portion of the profit. However, it is universally recognized that the circumstances of the engineering faculty member will depend very much on what happens to the national economies. There is a limit on how far one can
let the staff members search for additional income without sacrificing the quality of the tuition provided to students and this should be borne in mind.

Another tactical issue involving staff and brain drain is the modularisation of courses. This will enable institutions within the same country to exchange staff and hence mutually strengthen each others programmes. Visiting staff members when they are on short visits can take up one module rather than the whole course. Such modularisation will of course be accompanied by change of the academic calendar to a semester system.

The issue in this case is what the engineer requires or what sort of training he should receive in order to make him an "employment creator" and not an "employment seeker". The background to this is the big unemployment among engineering graduates on the continent. As a result of this strategic issue, two tactical issues were discussed. The first was the introduction of courses in entrepreneurship and management into the engineering education programme. The courses should train students on how to market ideas, how to obtain financial support for projects as well as economic analysis of projects. The second tactical issue was the adoption of national policy on the prevision of grants for the commercialization of ideas. This will enable graduates to start up projects after their education. While government policy makers would normally prefer to reduce unemployment by training according to the requirements established by manpower demand surveys, the experts felt that Africa is already too far below the critical manpower requirements in engineering and therefore it was argued that training must go on at full speed but that the graduates must be made to create jobs. A liaison or advisory service should be set up within faculties to provide information to graduates on how to survive on their own.
Africa’s numerous problems require an engineer with an open mind. Society expects that the Engineer should be able not only to reproduce known knowledge but to create new ones specifically for the solution of unique local problems. However to be creative, the student needs to be in an environment that enables him to understand the basis of the knowledge provided to him. He must live in a critical environment if he is to be creative.

At issue, were the mechanisms by which creativity can be developed in students. These include

- project work involving the study of new problems that may demand an innovative use of existing knowledge.
- interaction with the society/environment. Students must be encouraged to develop engineering solutions to major societal problems.
- several other tactics could be employed to broaden the horizon of students.

There are two aspects to this issue. The first is a demand and supply issue. At present, in most national institutions, the demand for space is more than that available. How do we cope with the demand or is there any need to admit more students? The answer to the latter will depend on whether a country decides to produce engineers in conformity with the demand for them in industry or in pursuance of a goal to build human resource capacity in all fields of science and technology. The second aspect of this issue is that of equity (particularly gender equity) in access to engineering education. An analysis of the problem of gender distribution in enrollment in engineering schools showed that it originates from the secondary school level. Hence the solution of the gender equity problem would have to be at that level. This is more so because retention of female students in engineering school is not deemed to be a
There are several aspects of this issue. These include answers to the questions: Why evaluation? What to evaluate? and how to evaluate? Evaluation is done to assure quality and to identify areas needing improvement. Evaluation is usually carried out on staff, curriculum, teaching and students. These could be carried out both internally (self) or externally. In the case of the evaluation of staff there is also the additional issue of system of reward for quality among staff. There are those who are good teachers and there are those who are good researchers. Promotion is usually the method of rewarding quality among staff. However, the promotion criteria are usually heavily weighted in favour of good researchers. It was thought that another system of reward (presumably financial remuneration) should be used for good teachers/administrators.

The evaluation method (in particular the weighing of different elements of the programme) for students will be very important in the future as various curricula put emphasis on practical work and creativity.

Parallel to the issue of evaluation is the issue of accreditation by foreign institutions. Many African universities would have to decide whether to accept the recommendations from the evaluation by accreditation committees, which is sometimes at variance with the needs of their society or comply with both requirements.

Many countries have introduced changes in their basic education programme which may affect the background of the freshmen entering engineering schools. For instance under the 8-4-4- and 6-3-3-4 system students are expected to enter universities after 12 years of schooling and should spend another four (4) years in the university. At the moment students who spend four years on a degree usually enter after 14
years of schooling. Those who have twelve (12) years of schooling spend five (5) years in college. Thus total education of an engineer currently ranges from 17-18 years as opposed to the 16 years now being proposed. There is therefore an obvious issue of the type of curriculum and the entry requirements.

In future, African engineering institutions will have to completely their curricula to reflect changes in the education system as well as the demand from industry and society in general. The tactical issue in the curricula revision will be the involvement of industry and the identification of new roles for engineers in the society. New courses would be developed from these issues. Most of the strategic issues that were raised will ultimately require a review of the curricula.

The crisis, (financial, human and material resource availability) obviously means that Deans /Directors of engineering schools in Africa, would have to adopt innovative techniques for delivery of engineering education. There are several tactical issues involved in innovation in engineering education. These include: production of teaching/learning materials; new teaching methods that will require less staff; innovative staff development programmes that will facilitate staff retention, innovative approaches to maintenance of laboratory facilities and simulation of laboratory experiments. Over the next few years institutions will have to adopt different tactics to deal with the above-mentioned issues.

Although there is good international collaboration based on historical links, there is not much link among institutions within the region. In order to pool resources together so as to strengthen the various programmes, particularly to overcome the staff shortage, regional collaboration is going to be a very important issue in the future. Staff exchange and postgraduate student exchange will be some of the elements of such collaboration.
After careful discussion of the problems, constraints in engineering education in Africa, several strategic issues were highlighted. Further examination of these issues led to the recommendations given below. There were three types of recommendations made on most of the issues. One type was directed at the attention of engineering institutions, another set was for action by national governments and finally some of the recommendations would demand action from international organizations. Each of the recommendations given below will indicate the expected target for action.

In order to generate adequate funds for engineering schools to be able to provide the services for which they were set up, it was recommended that engineering institutions should do the following:

**(i)** They should aggressively pursue the traditional means of income generation such as consultancies/research contracts/continuing engineering education programmes for industries.

**(ii)** Students should be made to pay for services in the engineering schools.

**(iii)** Technical departments of engineering schools could be upgraded to provide services.

**(iv)** National Governments should impose relevant training levies on industries. The fund generated may be managed by the various engineering councils responsible for registration of engineers or government bodies for onward transmission to the engineering facilities.

In order to overcome the constraints from the lack of human, physical and financial resources the following recommendations for the administration of engineering institutions were made.
In order to overcome the weaknesses and constraints of institutions in the region, it is recommended that engineering institutions pool together their resources to enhance their capacity. The strengthening of existing regional and sub-regional networks was strongly recommended.

Faculties should take advantage of centers of excellence in specific areas already in existence in the region, for example when planning new programmes and in the training of staff. Towards this end, institutions should be encouraged to maintain up-to-date data bases on expertise and
facilities, and a directory of these should be available from a central body such as the African Network of Scientific and Technological Institutions (ANSTI). The format for this database should be uniform and as developed by ANSTI. Universities should be requested to provide faculties with modern communication facilities such as electronic mail.

Recognizing that effective university-industry cooperation will enhance curriculum development, research and consultancy capabilities, increase financial base of the faculties, provide student sponsorship and opportunities for internship, attachment and realizing that such cooperation will provide industry with targeted in-house training and continuing education, it is recommended that:

(i) Independent units/bureau for industrial cooperation should be established within the faculties.

(ii) Faculties market their services and be sensitive to public relations.

(iii) A study be conducted at national level to identify capabilities and needs of industry.

(iv) Governments to formulate a deliberate policy/legislation to encourage university-industry cooperation.

(v) There should be decentralization of authority with respect to the management of Industrial cooperation units/bureaus and that a mechanism be instituted to scrutinize the allocation of consultancy jobs.

(vi) Endowed chairs in faculties by industry be encouraged and that the chair be supplemented on top of regular university salary.
STRATEGIC ISSUES IN ENGINEERING EDUCATION IN AFRICA

4.5 Training for Self-Employment

Noting that there is increasing unemployment of engineering graduates and aware that engineering graduates can employ themselves and create jobs for others:

(i) It was recommended that engineering schools should introduce entrepreneurship courses in the engineering syllabuses.

(ii) It was also recommended to further the concept of entrepreneurship for the engineering graduates by encouraging the study of success stories, identifying their characteristics and developing a model.

(iii) It was recommended that the engineering schools should use the final year projects as a basis for imparting business skills or as a basis for commercializing the students' ideas.

(iv) Institutions should use industrial attachments to expose students to entrepreneurship ventures.

4.6 Developing Creativity in Students

Creativity in engineering is very important in Africa where it is often necessary to improvise solutions using locally available materials and components. Creativity is a characteristic of an individual and cannot be imposed. However its development can be encouraged by creating an enabling environment and by undergoing suitable experience. It was therefore recommended that to create this enabling environment:

(i) contact should be encouraged between students and professional engineers and other professionals through talks, lectures and demonstrations to create awareness in them of the dynamism of technology and society.

(ii) industrial attachment of students should be organized.
In most African countries, pre-university education lasts for a minimum of 12 years while engineering degree programmes last for 4-5 years. The workshop therefore recommended as follows:

(i) A minimum of 12 years of pre-university education and a total of 17 years of schooling was recommended for one to be awarded an engineering degree.

(ii) Recognizing the importance of practical training in the education of engineers, the workshop recommended that: Engineering training at University level, must include a compulsory period of practical training in industry which is supervised and assessed. The practical training must be part and parcel of the approved curriculum. It was suggested that the total time spent on practical training be a minimum of six months.

In view of the fact that very few engineering institutions have revised their curricula over the last two decades, it was recommended that urgent steps be taken to re-design the curricula.
Evaluation and assessment of engineering education is necessary because the institutions are ultimately accountable to their clients (the students and employers), society (government) and the engineering profession itself.

Evaluation must be carried on the following
• the programme itself
• the staff and
• the students

4.9
Trends in Evaluation and Assessment

(i) Engineering curricula should be designed taking into account industrial, societal and professional needs. The design and review process should involve academic staff, government ministries, professional bodies, industry, past students and society in general.

(ii) Engineering curricula should provide a good balance between theory and practice, and should include contact between students and practicing engineers.

(iii) Engineering curricula should include and emphasize supportive courses such as those on environmental issues, communication skills and entrepreneurship.

(iv) Engineering undergraduate and postgraduate curricula should be developed to include non-traditional disciplines created by technological change such as new materials, bio-medical engineering and manufacturing engineering.
STRATEGIC ISSUES IN ENGINEERING EDUCATION IN AFRICA

(i) With respect to the programme it was recommended that all institutions should have a mission statement and a clear set of objectives to be achieved and strategies to be used. The programme can then be evaluated on the basis of how far those objectives have been achieved. The programme should be evaluated regularly and monitored using both internal and external indicators.

(ii) Evaluation of staff should take into account their contributions to teaching, research and administration. For promotion purposes teaching and service to community should also be taken into account in assessing candidates below the level of senior lecturer. Promotion to professor level must be based on research. The issue of transparency is, however, strongly desirable in this regard. Transparency could actually help stem the brain-drain.

(iii) It was recommended that student assessment take the usual form of coursework and examinations in various proportions.

4.10 Access and Retention to Engineering Education

In view of the low enrollment of certain disadvantaged groups, especially women, in engineering institutions, it was recommended that:

(i) Governments should make efforts at pre-university level (viz. primary and secondary schools) to increase participation of females in science.

(ii) Engineering schools should increase female enrollment to 10% by the year 2000 and to 20% by the year 2015.

(iii) Engineering institutions should look into experiences of other countries (Asia, China, India, Ghana, Latin America)
where females have made notable inroads into engineering with a view to adopting relevant strategies in national programmes.

(iv) International organizations should facilitate networking of female engineers in the region.

(v) Governments should make deliberate efforts to equip schools with basic facilities for teaching of science.

(vi) Governments should take measures to provide scholarships for disadvantaged groups to enhance their access to and retention in engineering schools.

(vi) Engineering schools should make entry requirements more flexible with a view to admitting a wider variety of students (e.g. young mothers, mature students etc.)

(vii) That access should not be tied up entirely with technical manpower survey. It was recommended that engineering schools should expand their enrollment to enable full utilization of capacities.

(ix) That efficient and effective utilization of resources should be improved to facilitate enhanced intake into engineering schools.
APPENDIX

1

List of Working Documents

A
Commissioned Papers


3. Halfani, M.R.: Gender and other equity issues in access to engineering education in Africa - Department of Chemical Engineering, University of Dares Salaam.


B
Country Papers


6. Gundyanga, F. and Chinyamakobvu, O. S.: Engineering graduate unemployment - The Zimbabwe Perspective - Faculty of Engineering University of Zimbabwe.

7. Akuffo, F. O.: University of Science and Technology, School of Engineering: Vision 2015-

(Extracted from World Bank Technical paper No, 197- Africa Technical Department Series on “Assessing Engineering Education in Sub-saharan Africa)


10. Fraser, Malcom: Different Methods of Assessment - Director and Chief Executive of the Council for National Academic Awards in the U.K.


# APPENDIX 2

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STRATEGIC ISSUES IN ENGINEERING EDUCATION IN AFRICA

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