Engineering Education for Industrial Development: Case Studies of Nigeria, Ghana and Zimbabwe

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ATPS Working Paper No. 42

Published by theAfrican Technology Policy Studies Network, P.O. Box 10081, 00100 General Post Office, Nairobi, Kenya.

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ISBN 9966-916-64-4

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Executive Summary

This project was carried out to evaluate the capacity for university engineering education in three African countries, south of the Sahara - Nigeria, Ghana and Zimbabwe with a view to assessing the extent to which the programmes prepare graduates for their prime role in industrial development. Five main issues were investigated in depth:

- government policy on engineering education
- resource capacity for engineering education (funding, student enrolment, availability of teachers and trainers, laboratories, workshops, classrooms and library facilities)
- course structure and content
- post qualification on-the-job performance of graduates
- females in engineering education

Data were collected through desk research, administration of questionnaires and in-depth interviews. The respondents were selected groups of students, teachers or trainers, graduates, employers or supervisors, and policy makers. Employers were selected from public and private sectors and from manufacturing and engineering fields. The policy makers interviewed included vice-chancellors, bursars, university librarians, deans of faculties of engineering, chief executives of relevant government parastatals, and heads of engineering societies and regulations bodies.

None of the countries has specific policies on engineering education but all have fairly comprehensive and similar policies on technical education designed to facilitate the production of qualified technologies for industrial development. The policies for Nigeria and Ghana were formulated apparently without any baseline data on supply and demand for engineering graduates but Zimbabwe has a fairly comprehensive data base.

The thrust of the policies is the introduction of technical subjects at the secondary school level, complemented by intensive practical work. At the tertiary or university level, the curriculum is designed to give the student maximum exposure to practical work as well as the industrial experience, both of which are prerequisites for engineers capable of leading industrial development. However, the results of this study show that none of the three countries has succeeded in providing the resource capacity for articulating these policies. Most of the institutions have no modern laboratory equipment; funding is extremely low despite an increase in student enrolment; shortage of academic staff varies from about 20 percent in Zimbabwe to about 60 percent in Nigeria (Ghana has no staffing problem); library facilities are below standard (although the situation in Zimbabwe is much better than in the other two countries). The situation in Nigeria is the most precarious, apparently owing to the proliferation of tertiary institutions offering engineering courses — 25 facilities of engineering compared to two in Zimbabwe and one in Ghana.

Students complain of inadequate exposure to practicals although they are generally satisfied with the quality of education. Employers are also generally satisfied with the performance of graduates on the job and the way they respond to any additional training given. However, they complain of inadequate exposure to practical engineering and management courses, and poor communication skills.

There is little or no faculty-employer interaction in any of the three countries in the areas of curriculum development, research or consultancy. The problem appears to be due to lack of initiative on the part of engineering faculties. This is at variance with the situation in the developed countries where there is close, mutually beneficial faculty-industry cooperation.

Placement of students for industrial work experience is problematic, the situation being less serious in Zimbabwe than in Nigeria and Ghana. Also, industry is generally unwilling to provide the supervision needed for gainful experience.

The curricula in the three countries is deficient in management and entrepreneurship education and therefore do not prepare students entrepreneurship or self employment.

Academic staff in the three countries generally have very little exposure to engineering practice. Most of them, although well trained, have never had any industrial experience beyond what they had under the student industrial work scheme during their training. Also, many have never visited relevant local industries or participated in consultancy activities. This is considered a major deficiency in their capacity to provide adequate training to students.

The study shows that females are grossly under-represented in engineering education; they usually constitute less than 10 percent of the student population. The bulk of those who choose engineering usually opt for the "soft" engineering courses — computer science and engineering, electronics, food science, and technology. Very few (less than 5 percent opt for the traditional engineering courses — civil, mechanical and electrical engineering. The main problem appears to be the socio-cultural belief that engineering is heavy, dirty, masculine and unsuitable for females and the consequent tendency of parents, staff and student colleagues to discourage females right from the secondary level from taking science courses. There is no indication that females are intellectually inferior to males in engineering courses. Those who opt for the courses tend to do as well as, and sometimes much better than, their male counterparts. Most respondents agree that females should be encouraged to take up engineering careers through counselling, provision of special scholarships and admission quotas. Most do not agree however that lower cut-off points should be set for females as it might put them at a psychological disadvantage.

In view of the findings summarized above, the following recommendations are proposed:

i) There is a need for greatly improved funding for engineering education, pivotal role in economic and industrial development on any nation.

ii) Funding and resource capacity could be greatly improved in Nigeria with intoduction of fewer faculties of engineering, each designated as a centre of excellence in specific areas of specialization. The example of Zimbabwe is useful. The second faculty of engineering in Bulawayo which was established in 1991 offers courses which are different from those offered by the University of Zimbabwe. One way of improving funding is to introduce academic fees. Zimbabwe has already introduced fees but Ghana and Nigeria have not, although recommendations have been made to both governments. It is difficult to see how any university in the region can continue to provide free qualitative education, considering the decline in economic fortunes of the countries in the region.

iii) The poor teaching staff complement in Nigeria compared with Ghana and Zimbabwe could he improved by rationalization of faculties, and better conditions of service.

iv) The policy on engineering education in the three countries, if implemented, would go a long way in stimulating industrial development. The problem has been provision of the wherewithal for implementation. The way forward is for each government to provide funds to strengthen the teaching of science, technology and vocational subjects at the secondary school level and to avail equipment for practical classes at the tertiary level.

v) The engineering curricula in each country needs to be restructured to include more subjects on management, entrepreneurship and technical report writing.

vi) It should be mandatory for faculty boards of engineering in each of the three countries to have industrialists as members who should also participate in curriculum review.

vii) Teachers and trainers should be supported to spend short periods and sabbatical leave in industry.

viii) Compulsory industrial internships should be scheduled for the final year by all faculties of engineering. Students should be required to pay for such internships at the beginning of the session and reports emanating from such visits should be graded on a pass or fail basics, in the same way student industrial reports are treated in most universities.

ix) There should be mandatory periodic evaluation and review of engineering curricula, say every five years, by teams comprising both academics and practising engineers. This is being done already in Nigeria by the National Universities Commission (NUC) and the Council for Registration of Engineers (COREN).

x) Deans of faculties of engineering should actively encourage departments to foster a close relationship with relevant industries. This is the trend in developed countries and substantial funds and equipment often emanate from industry to support research and consultancy problems of interest to industry.

xi) The Student Industrial Work Experience Scheme programme in each country needs to be restructured to ensure better faculty-employer involvement in the design and supervision. Faculties of engineering should have strong industrial placement units, headed by experienced engineers. This is already a requirement stipulated by NUC for every faculty of engineering in Nigeria. There should also be a way of compensating employers for providing placement for students on industrial training. In Zimbabwe, placement of engineering students appears to be relatively easy but it is problematic in Ghana and Nigeria mainly because employers are reluctant to take students, having paid the mandatory annual tax levied by government for the Student Industrial Work Experience Scheme. The problem in Nigeria is exacerbated by the very large number of students who have to be placed each year, compared with the relatively few number of the suitable industries. Even when students are accepted, they are often not well supervised.

xii) Each of the three countries has a policy on the promotion of female education but there is none in place on female technical education. The major barrier to female technical education appears to be at the secondary school level and could be reduced through career counselling and by provision of scholarships for females who opt for SMT subjects.

Chapter One

Statement of the Problem

Industrial development is a process by which a nation acquires competence in the manufacturing of equipment and products required for sustainable development. Technology is considered the prime mover. Engineering is the specialized aspect of technology which deals with the design, development and evaluation of technological processes and equipment. Engineers provide the leadership in technological manpower development in any nation. Other components are technicians and artisans. While each of the three cadres is important in stimulating technical and industrial development, it is the engineer who, by training, is most components to provide the thrust for the acquisition, adaptation and diffusion of technology.

Despite the existence of engineering institutions in Sub-Saharan African that have been graduating hundreds of engineers annually for about four decades, there has been little progress in the acquisition and effective utilization of technology for industrial development. Most industries in the region still depend heavily on imported technology and equipment, and on imported technical expertise for maintenance. One of the main reasons for this problem may be the type of training given by these institutions, most of which are more or less carbon copies of foreign institutions. There is a growing need for curriculum review, with a view to making training more relevant to the needs of developing nations. In order to do this effectively, a diagnostic review of the present curricula is necessary. It would be useful to identify the defects and seek the opinion of current students, graduates, employers and policy makers.

Chapter Two

Literature Review

Development in Sub-Saharan Africa

Development is defined as a sustainable increase in living standards that encompass material consumption, education, health and environmental protection (World Bank, 1991, p.31). Indicators of development include the ability to meet basic needs for food, education and healthcare. *Table 2.1* shows the Human Development Index (HDI) ratings for some of Sub-Saharan African countries compared with industrial and industrializing countries. Botswana (HDI 0.670) has the highest in the region and is the only country in the region rated among the first 100, while Guinea's rating is lowest in the world. Economists have traditionally considered an increase in per capita income to be a good proxy for these indicators of development. They assume that growth in per capita income induced by growing productivity is the engine of development. What drives productivity? The answer is technological progress (World Bank 1991, p.4).

In a recent study by Gapanski (1996), using economic variables of output, labour and productivity growth rate over the period between 1951 and 1990, it was shown that African countries are far behind OECD countries in economic growth. Even within Africa there is a wide disparity and it is possible to group the countries of Africa into two: Group A comprising Algeria, Egypt, Morocco, South Africa and Tunisia and Group B encompassing the remaining 43 countries. The development variables for each group and OECD countries are shown in *Table 2.2*. All the countries in Sub-Saharan Africa except South Africa fall in Group B.

A central issue in technological development is industrial development. Technological development is motivated and driven by industrial development, which in turn promotes the development of the capability to manufacture goods, particularly capital goods. Development has almost always involved a shift in the sectoral composition of output. Agriculture's share of production and employment, which is typically high at the early stages of development, begins to decline while that of manufacturing industry tends to increase.

Table 2.1 Human Development Index Ratings of some Countries

Country	HDI Values (Max . = 1.000)	World Rating
Botswana	0.670	87
South Africa	0.650	93
Zimbabwe	0.474	121
Congo	0.461	123
Cameroon	0.447	124
Ghana	0.382	134
Cote d'Ivorie	0.370	136
Nigeria	0.348	139
Canada	0.932	1
Japan	0.929	3
United Kingdom	0.919	10
Germany	0.918	11
South Korea	0.859	32
Singapore	0.836	43
Malaysia	0.499	57

Source: Human Development Report, 1994. UNDP

Table 2.2: Economic growth in African countries compared with OECD countries. (Output Y is measured in billions of 1985 international dollars, Labour L is given in millions of workers, and productivity growth rate in percent Gapanski, 1996)

Group	Output Y	Labour L	Productivity Growth Y
Group A Africa	39.4	5.9	2.4
Group B Africa	5.6	3.3	1.4
OECD Countries	290.4	13.7	3.0

A major prerequisite for this transformation is the acquisition of technological capability that is, the ability to select, diffuse, develop or adapt technology and build on imported technology. Countries that have experienced rapid growth in manufacturing capability in recent times, notably Japan, Korea and Taiwan have adopted the strategy of importing and building on established technology from abroad (World Bank 1991, p.90).

Education, particularly technical education is considered to be a prime stimulant for the development and growth of endogenous technological capability. Japan's rapid industrialization was fuelled by the accumulation of technical skills which in turn was based on its already high level of literacy and a strong commitment to education, especially the training of engineers. Korea adopted a similar strategy about 50 years ago by launching strong education programmes focused on universal primary education, utilizing both internal and external training facilities (Pack and Westphal 1986). Education affects economic and industrial growth in many ways: it hence enhances the ability to imbibe and adapt technological innovations. It promotes entrepreneurship and entrepreneurial ability characterized by a combination of moderate risk-taking, individual responsibility, long-range planning, and organizational ability. Education also has a positive influence on enterprise size and productivity. Recent studies indicate that increasing the average amount of primary education of a labour force by one year raises GDP by 9 percent (World Bank 1991, p.43).

In a recent study, the World Bank (1998) identified lack of capacity as one of Africa's most disenabling problems, cutting across the entire range of challenges to national development, from policy analysis to effective delivery of basic social services. Capacity building through education was identified, as the region's most important need to catalyse its economies to sustainable growth.

The report observed that, despite some improvements in revenue allocation to the education sector in recent years, the problems of policy implementation have made such substantial resources irrelevant to capacity building in the vital sector. The problem is exacerbated by the low school enrolment rate in the region, which is the lowest in the world, and the low adult literacy rate which is estimated at about 53 percent.

Another recent report by the United Nations (1998) examined critically why investments in education in Africa have failed to seriously alter the level of poverty, the extent of employment and the degree of inequality, all of which are indicators of true development. The report adduced many reasons why education has failed to catalyse the development process in the region:

> One of this is that sufficient resources and commitment have not been invested in education on a sustained basis. Funds allocated to education in most African countries have always been too little, too late to make the needed difference...This tokenism to such a critical input in human development has reduced commitment administrators and teachers and consequently the quality of products of educational institutions... a situation where schools lack basic instructional materials, where libraries lack relevant books and laboratories suffer from shortage of basic apparatuses and reagents does not augur well for qualitative education...Half-baked graduated or high school products of dubious quality can hardly be expected to midwife an education-led development breakthrough... aside from the chronic shortage of resources that has crippled educational curriculum and faulty orientation that make most products of our higher institutions helpless unless they can secure jobs in government ministries or the organized private sector.... For education to be a tool for rapid and sustainable development in Africa, it must be functional, it must be culturally relevant and emphasise technical competence...

Table 2.3: GDP Per Capita for Various Regions of the World

Region	GPD/Capita	Growth Rate
	1989	1950-89
Asia	2,182	3.6
Latin America	3,164	1.2
Sub-Saharan Africa	513	0.8
Europe, Middle East & North Africa	2,017	2.0
Eastern Europe	5,618	2.0
OECD members	10,104	2.3

Adapted from World Development Report, 1991,*Table 1.1.* The World Bank.

Sub-Saharan Africa is considered the least developed region of the world, based on the development indicators outlined above. Despite the fact that most of the countries in the region spend substantial proportions of their annual budgets importing technology and the products of technology, there has been little progress in the acquisition of technological capability. The Gross Domestic Product (GDP) and the growth rate of GDP for the region are the lowest in the world (*See Table 2.3*).

Various reasons have been advanced for the poor state of the economic and industrial development of the region among which of the following are prominent:

- Over-reliance on the exportation of primary resources, which are very sensitive to external influences. The steady decline in world prices of primary commodities in the past ten years or so has created major financial problems for most African countries.
- Unrealistic, incoherent, poorly articulated and unstable development and industrialization policies.
- Political instability in most countries of the region.
- Lack of basic infrastructure required for economic and industrial development.
- Wrong strategy for the acquisition of technological capability.
- Lack of adequate manpower with the right mix of skills and proper orientation to cope with the challenges of economic and industrial development.
- Dearth of first-rate entrepreneurs with managerial skills, who are capable of mobilizing the human and material resources of their nations into productive enterprises.

Although Sub-Saharan Africa is considered to be short of skilled manpower, particularly in the crucial areas of science, engineering and management, there is a growing feeling that the available number is enough to stimulate economic and industrial development. The problem is that most of them are either products of foreign educational institutions or local institutions, which are replicas of foreign institutions and are therefore ill-equipped to adapt to local conditions. The recent collapse of the economies of most of the countries as a result of the global depression of the primary commodity market, has in fact accentuated unemployment among the youth and the educated. In Algeria, nearly 50 percent of the estimated unemployed is in the 16-24 age group. Corresponding figures are 50 percent for Tunisia and 62 percent for Nigeria (*African Development Report* 1993, p.41). A notable characteristic of the employment profiles in Africa is the rise in the number of the educated among the unemployed. These include highly skilled university graduates who have been experiencing fewer opportunities for employment.

It is generally believed that the inability of Sub-Saharan African countries to assimilate, adapt and diffuse technology is a result of two major factors:

i) Lack of effective policy to proliferate technology awareness at all levels of the educational system.
ii) Serious shortcomings in the training of technical manpower

Economic development of nations depends critically on the ability of their societies to establish a sustained technological progress, many key aspects of which currently are changing at an unprecedented rate. Engineers play a crucial role in realising this process. The growth of a development plan for engineering education is to ensure that the required number of engineers of a specific standard are produced in an efficient manner. In the case of Sub-Saharan Africa, it is necessary to transform the present engineering education system into a new system that satisfies this development goal (The World Bank, 1990). Most of the studies that have been carried out on technical education in Nigeria have been on vocational and polytechnic education (Ehiametalor and Ogusaju 1985; Atiomo 1989; Aina 1989; Yebani 1992; Nnebe 1995). There appears to have been no study on engineering education. A joint conference of the Council of Registered Engineers of Nigeria (COREN) and the Committee of Deans of Engineering and Technology of Nigerian Institutions (CODET) held recently concluded that there were serious policy and structural defects in the engineering education system in Nigeria and called for a comprehensive evaluation, with particular emphasis on the relevance to the needs of the country (COREN/CODET 1991). The Executive Secretary of the National Manpower Board recently criticized the tertiary educational system in Nigeria as being unresponsive to the demands of the labour market and called for a review of the curricula and structure (Umo 1995). The proposed study is a response to the calls and is designed to critically evaluate the existing policies and structure of engineering education in Nigeria with a view to determining changes required to ensure relevance to the needs of their future work. The study will also be carried out in two other Sub-Saharan African countries to identify common problems, adopt positive experiences and identify possible areas of cooperation.

Technology and Industrial Development in Sub-Saharan Africa

Industrial development is a process by which a nation acquires competence in the manufacturing of equipment and products required for sustainable human development. According to Sutcliffe (1971), the purpose of industrialization is to provide a higher material standard of life for most of the world's population. Three main inputs are required for industrial development:

Human and financial resources

Labour (skilled and unskilled) is not only a major factor of production but must also be seen as the chief beneficiary for which the effects of industrialization and economic development are intended. Although the great majority of labour required for industrial development, particularly in developing countries, is unskilled, the nature of technical progress industry has continually been towards more mechanized techniques which require at least some workers with higher levels of education and increasingly sophisticated skills to operate them. In addition, increase in the level of literacy among the work force is known to greatly enhance productivity.

Capital investment is another major requirement for industrial development. Availability of adequate local and foreign capital is an essential condition for rapid industrial development.

Natural Resources

Traditional theories of industrial development place great emphasis on local availability of the required natural resources. The location of economic and industrial activity during the 19th century industrial revolution was crucially affected by natural resources. However, there is a growing feeling that availability of natural resources tends to stifle the development of the capital goods production capability. According to Chenery (1960), high-resource countries such as New Zealand, Denmark, and many African countries tend to have relatively low domestic production of machinery, transport equipment , chemicals, textiles and metals, and to compensate by high imports of these commodities, financed by primary exports. The low resources countries on the other hand (such as Japan, Italy, Germany and the United Kingdom) do the opposite. They offset low exports and high imports of primary products by high domestic production of these same groups of manufactured goods. Machinery is the sector most sensitive to resource endowment. A large proportion of it can be supplied more economically by imports when a country has a comparative advantage in primary production and exports. Japan has also proved conclusively that lack of natural resources can be adequately compensated for by the adoption of efficient production technology.

Technological Capability

Technological capability may be defined as the know-how needed to combine human skills and physical capital into systems for producing and delivering want-satisfying products. There is considerable literature on what it takes to acquire technological capability (Lall 1994; Ernst et al 1994; Mytelka 1995). Evenson and Westphal (1994) classify technological capability into three broad categories:

i) **Production Capabilities** pertain to the operation of productive facilities. They encompass various activities involved in product design, production management and engineering, repair cum maintenance, input sourcing and output marketing and so forth.
ii) **Investment capabilities** relate to the expansion of existing capacity and to the establishment of new production facilities. They embrace the many activities related to project selection,

design cum engineering,the execution as well as extension services and manpower training.

iii) **Invention capabilities** concern indigenous efforts to adopt, adapt, improve and develop technology.

Acquisition of capabilities in investment and production capabilities can be achieved through proper management of imported technology. This in turn can lead to the development of investment capabilities. This is aptly demonstrated by the experience of South Korea (Westphal et al 1984). Formal purchase of foreign technology provided the seed from which were developed tha capabilitiesto acquire vastly more additional elements of technology in a manner akin to apprenticeship participating with the foreign partners in project executionand start-up provided the initial learning.

Another method adopted for acquisition of additional technology was one of imitation through sequential reverse engineering leading to the emergence new of processes and products. The basic underlying principle was that of step-by-step mastery successively mastering individual elements in a progression running from the simpler to the more complex. This strategy has successfully launched South Korea as a major emergent economic power in the past 20 years or so. It also demonstrates clearly that an effective process of technological development through the focused acquisition of production and investment capabilities can provide the means to assimilate and then adapt a great deal of foreign technology on the basis of selectively importing some of the elements while developing the others locally.

Many African countries have also imported technology extensively in the past three decades or so and yet nearly all of them have not succeeded in acquiring technological capability. Evenson et al (1994), using selected technological capability indicators classified the countries of the world into eight levels of technological development as shown on*Table 2.4.* Most sub-Saharan African countries fall in categories 1a - 1c the group of least developed countries.

By contrast, South Korea, Taiwan, Singapore and Hong Kong all have achieved full Newly Industrialized Country (NIC) status since the 1980s and other previously technologically underdeveloped countries such as China, Indonesia, Malaysia, Thailand and Chile are on the verge of qualifying as NICs.

The main problem with African countries appears to be lack of public policy which explicitly promotes technological development through the accumulation and utilization of technological infrastructure. Take, for example, the effort of Nigeria in acquiring automotive manufacturing capability. Six assembly plants were commissioned at the same time on turnkey basis about two decades ago. There was little local participation in the crucial decisions on choice of technology and plant installation. There was no attempt to develop in parallel local content manufacturing capability, which is crucial to the success of the projects. There was no attempt to control the introduction of models, hence the wide range and frequent changes, which have made investment in local content manufacture unviable. There was no attempt to protect the local plants by controlling importation of fully-built vehicles. With the economic recession and scarcity of foreign

Table 2.4. Levels of Technological Development

Level	Technological Development Stage
1a	Traditional technology
1b	First Emergence
1c	Islands of Modernization
2a	Mastery of Conventional Technology
2b	Transition to the Newly Industrialized Countries (NIC)
2c	Newly Industrialized Countries
3	Recently Industrialized Countries
4	Industrialized Countries

Source: Evenson et al (1994)

exchange, four of the plants have closed down and the two still operating have less than 5 percent capacity utilization. Local content manufacturing capability is still restricted to low-technology components such as windscreens pressed from imported glass, batteries, tyres, seat covers etc. Similar examples abound in most Sub-Saharan countries. By contrast, India which has a population ten times that of Nigeria, commissioned only one assembly plant which produced only one model in 1948. The model which was based on a famous, phased-out British version has been retained to date. In the meantime the capability to manufacture every component locally was developed. A second model was introduced recently which happened to be a phased-out famous European model. An obvious advantage is that the tooling can be purchased cheaply and the production technology easily mastered. In order to protect the local industry, India also had in place very stiff tariffs on imported cars. Sutcliffe (1971) defines three criteria for measuring the extent of industrialization of a country.

i) The proportion of the national income that accrues from the industrial sector.
ii) The proportion of the industrial output that comes from manufacturing
iii) The proportion of the population that is employed in the industrial sector.

For a nation to be classified as industrialized, at least 25 percent of the GDP should derive from the industrial sector; at least 60 percent of the industrial output should be from manufacturing; at least 10 percent of the total population should be employed in the industrial sector.

Tables 2.5 - 2.7 show the values of these indicators of industrial development for some African and Asian countries. Most of the countries, except Ghana, would be classified as industrially developed on the basis of GDP alone. This clearly is not sufficient criterion for industrialization considering that, for Nigeria, for example, manufacturing accounts for only about 10 percent of the GDP (*Table 2.7*). The relatively high contribution of the industrial sector was from the petroleum sector. On the basis of percentage of labour force in industry, the African countries, except South African, fall well below the minimum of 10 percent required for classification as an industrialized country.

Table 2.5: GDP of some African and Asian Countries by Sector

Country	GDP/ Capita US$, 1991	Agric Production %of GDP	Industrial Production % of GDP	Services % of GDP
Nigeria	1,360	37	37	26
Ghana	930	53	17	30
Zimbabwe	2,160	19	32	49
Kenya	1,350	27	22	51
Cote d'Ivoire	1,510	38	22	40
Cameroon	2,400	27	22	51
Congo	2,800	12	37	51
South Africa	3,885	5	44	51
South Korea	8,320	8	45	47
Singapore	13,734	-	38	62
Malaysia	7,400	-	-	-

Source: Human Development Report, *1994, UNDP, Oxford University Press*

The capacity to manufacture goods such as machinery is considered a major indicator of the process of industrialization. Although the contribution of the industrial sector to the GDP is fairly high for many African countries (*Table 2.7*), the products of the sector usually comprise mainly of consumer goods, industrial raw materials, minerals, and electronic products and car assembled from imported components. Most of the industries in the sector also depend heavily on imported technology, imported machinery and equipment. The success of an import-substitution strategy for industrialization depends on availability and efficient use of local factor inputs, a growing capital goods producing sub-sector, and opportunities for sectoral linkages, (Thomas 1988). The sub-sector producing capital goods offers opportunities for such linkages, high value-added, and the acquisition of capabilities for production technology. This sub-sector is underdeveloped in most African countries. In Nigeria, for example, manufacture of capital goods is at a rudimentary stage and is virtually restricted to the informal sector. The first machine tools industry set up as a public project about twenty years ago and expected to stimulate the growth of the capital goods industry, is yet to manufacture any machines. The few machines that were produced initially were assembled from imported components and this line folded up after the first few years of operation.

Tables 2.8 and *2.9* show how some Sub-Saharan African countries fare compared with some industrializing Asian countries, using several indicators of industrial development.

Table 2.6: Labour Force Distributions of some Countries by Sector

Country 1992	Population (millions) % of	Labour force as population	% Labour force in			% of population in industrial sector
			Agric.	Industry	Services	
Nigeria	115.9	31	48	7	45	2.2
Ghana	16.0	38	59	11	30	4.2
Zimbabwe	10.6	41	71	8	21	3.3
South Africa	39.9	38	13	25	62	23.6
Kenya	25.3	40	81	7	12	2.8
Cote d'Ivoire	12.9	32	65	8	27	3.1
Cameroon	12.2	30	79	7	14	2.7
Congo	2.4	39	62	12	26	4.8
Singapore	2.8	65	-	35	65	42.3
South Korea	44.1	61	17	36	47	22.0
Malaysia	18.8	36	26	28	46	10.6
Sub-Saharan		39	67	0.8	25	3.1
World		45	13	31	56	14.0

Table 2.7: Manufacturing as percent of GDP and Industrial Output

Country	Industrial Production as % of GPD	Manufacturing as %of	
		GPD 1989	Industial output 1989
Nigeria	37	10	22.7
Ghana	17	10	58.8
Zimbabwe	28	25	64.1
Kenya	20	12	60.0
Cote D'Ivoire	24	17	70.8
Cameroon	27	15	55.6
Congo	35	9	25.7
South Africa	44	24	54.5
South Korea	45	26	59.1
Singapore	38	26	70.3
Sub-Saharan	34		
Industrial Countries	37		
World Average	37		

Source: Computed from Table 4, World Development Report, 1991. World Bank/OUP

Table 2.8: Industrial development indicators for some African and Asian States.

Country	Scientists & Technicians per 1000, 1991	R & D Scientists & Technicians per 1000, 1991	Science Graduates, % of Total Graduates
1990			
Nigeria	1.0	0.7	23
Ghana	1.5	-	23
Zimbabwe	-	-	12
Kenya	1.3	-	24
Congo	-	12.4	20
South Korea	45.9	22.0	53
Singapore	22.9	18.7	28
Malaysia	-	40.0	21
Sub-Saharan Africa	-	-	24
Industrial Countries	84.9	40.5	24
World Average	25.0	12.0	

Source: Human Development Report, *1994*, *UNDP*

Table 2.9 Value Added in Manufacturing in some African States

Country	Value Added in Manufacturing As % of Value Added in Industry, 1992
Nigeria	32.8
Ghana	67.8
Zimbabwe	71.0
Tanzania	65.5
Kenya	72.3
Algeria	18.4
Egypt	48.4
Guinea	14.4
Zaire	43.1
Zambia	69.6
Cote D'Ivoire	67.9
Cameroon	33.6
Congo	9.4

Source: African Report, *1993*, *African Development Bank*

Engineering Education and Technology Capability

One of the most important ways of promoting industrial development is the proliferation of general education. This greatly enhances the ability to assimilate technology and also promotes productivity. Two major indicators of a nation's commitment to education are the proportion of the population enrolled in schools and the level of funding of education. *Table 2.10* shows the values of these indicators for some African, Asian and European countries.

The level of development in science education is also an important indicator of the ability of a nation to develop industrially. There is a wide variation among Sub-Saharan African countries as shown in *Tables 2.11 and 2.12*.

Table 2.10: Schooling Indices and Level of Expenditure on Education in some African, Asian and European Countries.

Country	Schooling Index (maximum = 1)	Spending on Education	
		Per Capita ($US)	% of Total Public Expenditure
Nigeria	0.08	2.0	3.4
Ghana	0.24	14.0	24.3
Zimbabwe	0.21	62.1	24.6
South Africa	0.26	-	-
Singapore	0.27	382.3	20.2
South Korea	0.62	137.6	22.4
U.S.A	0.83		
Canada	0.82		
U.K	0.78		

Sources: World Development Report, 1991, the World Bank & Annual Abstracts of Statistics, *1993, FOS, Nigeria*.

Table 2.12: Distribution of Tertiary Enrolment by Field of Study in Sub-Saharan Africa, 1990.

Country	All Arts %	All Sciences %	Maths & Eng. %	Females as % of total in inrolment sciences
Nigeria	53	43	12	-
Ghana	58	41	13	14
Zimbabwe	78	18	12	1
Guinea	39	61	19	11
Guinea-Bissau	42	58	58	8
Tanzania	38	62	38	9
Mozambique	39	61	32	22
Benin	80	19	3	11
South Africa	56	44	5	45
Total Sub-Saharan	62	35	6	20
Weighted mean median	67	32	4	14

Source: Donors to African Education, *1994. (UNESCO PARIS.) A Statistical Profile of Education in Sub-Saharan Africa*

Global Perspectives in Engineering and in Technology Education

The scope of engineering and technology is changing very rapidly worldwide and the adequacy of most training curricula is being called to question. Most employers of engineering labour all over the world believe that the products of engineering institutions are deficient in many ways and are not well prepared for future employment. The problem was highlighted recently by Clifford Smith Jr., the Chief Executive of one of the world's largest employers of engineering labour General Electric of America. (Smith, 1996) In his words:

> For the most part, we find the new college graduates lack a business perspective and awareness of, or competence in leadership skills. By leadership skills, I mean those skills required to mobilize resources across functional specialties, to introduce new initiatives, and frankly, to make technology pay off at the bottom line... New lines have little understanding of the role of the corporation. They do not have the flexibility required to function effectively in it. And they lack the critical skills required by today's work place: listening, communicating, defining problems, leveraging the skills of others in teams and functioning effectively in an ambiguous, complex and rapidly changing environment they are still too divorced from the needs of business. A multiplicity of factors should influence the education and the formation of the modern engineer...

In a recent study commissioned by the American Society for Engineering Education and carried out by a joint committee of Engineering Deans Council and the Corporate Round Table recommended that colleges of engineering must re-examine their curricula and programmes to ensure they prepare students for the broadened world of engineering work. In particular, they recommended that engineering curricula should such important topics as communication skills, team skills, leadership, ethics and an understanding of the societal, economic and environmental impacts of engineering decisions.(ASEE, 1995)

Engineering institutions globally are also under severe pressure to close the 'cultural gap' that exists between industry and academia. Interaction between engineering faculties and industry could be of immense mutual benefit as it:

- promotes steady exchange of knowledge and skills between the engineering faculty and industry.
- provides opportunities for both students and staff to acquire industrial experience, practical skills and awareness of the most urgent needs of industry.
- provides industry with ready access to sophisticated research equipment usually available in engineering institutions and relevant research results.
- provides access to industrial funding of mission-orientated research.
- helps to stimulate entrepreneurship skills in students as a result of interaction with industry.
- facilitates the input of industry into curriculum development. Through such cooperation, curricula which are more relevant to the needs of industry and society can be evolved.
- helps to remove the traditional suspicion by industry of research activities and results of engineering faculties.
- promotes technical liaison faculty members and industry in the form of consultancy.

In a study on strengthening co-operation between engineering schools and industry, Fishwick (1983) identifies a number of possible areas of cooperation:

- constant and continuous exchange of ideas on curricula between faculty and industry.
- inclusion of well-chosen industrialists in engineering college advisory boards·
- the use of practising engineers as part-time teachers to lecture on real industrial problems, industrial organization, management, up-to-date technology and similar topics.
- consultations with industry in order to identify relevant topics and new areas where progress or new knowledge is needed. Topics suitable for student projects can also be identified.
- acquisition of equipment no longer needed by industry but which could still be useful in teaching and research.
- access by industry to sophisticated, expensive instruments available in engineering colleges.
- visits by students to industrial enterprises and laboratories during their studies.
- acceptance by industry of students for industrial training
- cooperative industry-based research projects.
- access by industry through consultancy to the rich basic engineering knowledge available in engineering colleges which may be very useful in solving specific industrial problems.
- secondment of practising engineers to colleges and provision of industry positions for college faculty on sabbatical leave of leave of absence.
- offer of short- term professional development courses to industry by engineering college

staff who are usually more current on latest developments in engineering and technology, or for industrial staff wishing to upgrade themselves without leaving their jobs.

- joint conferences, seminars, colloquia on topics of mutual interest.

Pre-requisites for Good Engineering Education and Training and the Experience in Sub-Saharan Africa

A good engineering education must involve:

- adequate training in engineering principles, concepts, design.
- adequate exposure to practical demonstration of the most important engineering principles and concepts in the laboratories.
- training by teachers who themselves are current in the latest developments and who have relevant industrial experience.
- adequate knowledge of the latest developments in the specific area of specialization.
- adequate exposure to real life industrial environment during training through excursions to industry and industrial attachment.
- acquisition of a good working knowledge of management principles and practice.
- pupillage after graduation under supervision of senior engineers for a period of at least two years.

A good engineering education curriculum should also include entrepreneurship education. This is particularly important in Sub-Saharan Africa in view of the rapidly shrinking regular job market due to the economic downturn. A well-trained engineer should be able to see the self-employment option as a viable alternative to paid employment.

Studies carried out by UNESCO on engineering education have identified the three main elements of an engineering curriculum design as problem definition, structuring of the curriculum and implementation and evaluation of the resulting curriculum. (Zymelman, 1993). There is little doubt that most engineering education programmes in Sub-Saharan Africa give good grounding in basic engineering principles and concepts, judging from the way graduates of the programmes usually excel on postgraduate programmes in the developed countries. In fact, many of them eventually take up employment in major educational institutions and industries in developed countries. However, most of the programmes have major deficiencies:

- There is grossly exposure to practicals. In fact, some engineering programs are known to graduate engineers with hardly any practical classes. They teach only “theory of practicals” but every good engineer knows that there is no substitute for practicals.
- Most of the teachers of the programmes are grossly out of date on the latest developments in the field due to poor library facilities and little opportunity to travel to the developed countries.
- Most of the teachers have never had any exposure to practical engineering in industry.
- There is very little engineering institution industry interaction, hence the institutions generally are not familiar with the needs of industry.
- There is little or no industrial training under supervision either during training or after.

- Many curricula in Sub-Saharan Africa do not include training in management principles or entrepreneurship.
- Most of the engineering graduates are ill-prepared for the possibility or indeed likelihood that they may be required to take on professional responsibilities of enormous importance much earlier than their counterparts in industrial countries.
- Despite the rapid developments in instructional methods and technology using audio-visual techniques and computers, most countries in Sub-Saharan Africa lack the facilities for students to benefit from them.

A comprehensive review of engineering curriculum in Ghana was carried out recently (Ntim, 1993). The problem definition which involved all interested parties government, professional and educational institutions and industry led to the development of a set of five objectives. The set of objectives is applicable to most developing countries but the actual translation of these objectives into curriculum must take due account of each country's engineering workforce profile and the peculiar needs based on the country's development strategy and goals.

Koso-Thomas (1993) has raised two major questions on engineering education in Africa, which must be answered in order to properly channel scarce resources into the engineering education system: Should engineering education for Africa be standardized, and what level of theoretical and practical knowledge is required for professional practice in Africa? The consensus on the first question is that standardization of the curriculum would be undesirable. Since content of courses must be related to knowledge levels demanded by employers as well as to the socio-cultural complexion of the working environment. Despite this need, Koso-Thomas suggests that there must be a love of knowledge around which various components influenced by contextual factors could be fitted. It should be possible therefore to develop a standard care curriculum which would serve the need of every country in the region. Some degree of standardization will facilitate the pooling of manpower resources for regional development, the promotion of increased mobility of skilled personnel within the region and, perhaps, to a much greater extent, the achievement of a more economic and efficient education through the sharing of training facilities in regional centres of excellence.

The answer to the second question raised by Koso-Thomas is more controversial. One view on the issue is that engineering cannot be Africanized. An engineer trained in Africa should be able to operate in any part of the world without any problem (Koso-Thomas, 1970). Other views express the need for African engineering education to concentrate on aspects which are readily applicable within African communities (Shojobi, Kwakye, Brown, 1970). These contrasting views on engineering education indicate that the definition of appropriate standards for training engineers in Africa cannot be an easy task. It will not be prudent to give the impression that Africa should be relegated to training engineers for an age that has passed. At the same time, it will be unrealistic and counter productive to concentrate on producing engineers with a mastery of the most advanced subjects on the frontiers of knowledge, when most of them cannot be absorbed by the labour market or solve local developmental problems.

The review of the engineering education system in Ghana indicated that 80 percent of the engineers are engaged in the operation and maintenance of the various manufacturing enterprises, utilities, mines and construction companies, over 19 percent in consultancy services, and less than one percent in research and development, Although figures are not available for other countries in the region, this work force profile is probably typical. Based on this assumption, Koso-Thomas (1993) suggests a set of seven objectives of engineering education that will produce and engineer who would be employable as well as within the African labour market as follows:

- The provision of relevant technical and managerial skills, particularly for small industries.
- The encouragement of entrepreneurship.
- The imparting of basic knowledge of local scientific and technological capabilities and possibilities.
- The development of awareness of the socio-cultural and environmental problems of selected areas of the region.
- The Provision of adequate communication skills.
- The Provision of adequate practical orientation and the development of an attitude to work which produces desirable results.
- The development of skills for problem identification and solution.

A key element in the development of technological infrastructure to promote technological change, industrialization and acquisition of technological capability is the availability of competent technical manpower capable of conceiving, designing, installing maintaining and managing productive enterprises successfully. Many African countries have rich pools of technical experts comprising artisans, technicians and engineers, many of them trained in reputable institutions in the developed world. Many of the countries have also set up reputable training facilities of all levels of technical manpower. For example, Nigeria has established about 150 trade centres of polytechnics training artisans and technicians, and 36 universities, 27 of which offer engineering courses. Also tertiary level enrolment for science and applied science courses is high in many African countries. However, enrolment for secondary technical courses is generally low*(Table 2.11)*.

The engineer is trained primarily to originate to adapt existing designs of equipment and processes. His training must fully equip him with the capability to lead the technical manpower of a nation in achieving technological and industrial development. The problem with engineering education in Sub-Saharan Africa is traceable to the origin of the programmes of training. Many of the institutions were colleges of foreign institutions before they became autonomous and curricula adopted from the parent institutions have not been revised in many cases. Many of the institutions had or still have substantial numbers of expatriates and large numbers of foreign-trained indigenes on their staff. This is typical of many developing countries whose education system was aptly described by Sutcliffe (1971) as “a system of education which is too much a mirror of Western education and too little designed to provide skills and training which are relevant to economic development”.

Faruqui (1986) described the systems as "carbon copies of those of institutions in the industrialized countries". Several other authors have described the higher education systems in Africa as irrelevant and incapable of producing skills and training which are required for technological and economic development. It does not prepare the graduates for the world of work and does not inspire in them the culture of entrepreneurship (Isoun 1987; Scott 1989; Singh 1991; COREN/ CODET 1991; World Bank 1991; Nielsen 1995; Mihyo 1995; Umo 1995; Adekola and Obe 1995. The Federal Ministry of Finance (1992) identified the need for curriculum reform and upgrading of facilities in higher institutions as major components of the multi-sectoral needs.

Manuel Zymelman (1993) recently described engineering education in Sub-Saharan Africa aptly as follows:

> Engineering education in Sub-Saharan Africa is in a sorry date. Developed countries graduate 166 times more engineers per capita than do the countries of Sub-Saharan Africa, and the quality of training, already low, is deteriorating as a result of budget constraints. This deterioration of quality is most worrisome. For without a steady increase in quality to enable engineers the technicians to keep up with international technological advances, the countries of Sub-Saharan Africa will fall further and further behind.

Questions are also being raised on the relevance of engineering education curricula in Sub-Saharan Africa to the developmental needs of the region. Most of the institutions have no clearly defined mission goals on the type of engineers they are trying to produce. Deciding on an overall objective is crucial to the evolution of an appropriate engineering curriculum. For example, the type of program that would be suitable for training an engineering scientist or a specialist engineer would be inappropriate for the training of flexible engineers who are capable of adapting rapidly to new challenges in engineering. Engineering education programmes in the developing countries tend to concentrate on imparting a thorough understanding of science and engineering concepts. Although there is usually some supplementation with practical classes, the acquisition of engineering skills is after graduation when the graduate has to work under guidance and supervision of senior engineers for specific periods. Most of the engineering curricula are carbon copies of those of the developed countries. However, facilities for practical classes are usually grossly inadequate and most of the graduates have little or no opportunity to serve pupillage on the job. In fact, engineers in the developing countries tend to rise to management positions much more rapidly than elsewhere. It is not unusual to find a fresh graduate heading a critical engineering section, particularly in the public sector. There is therefore an urgent need to review the engineering curricula in Sub-Saharan Africa, taking full account of the developmental needs of the region and the probable job opportunities.

Female Engineering Education Female Engineering Education

Despite the number and high quality of studies and research projects carried out in various countries, information concerning women in engineering is still scanty and fragmentary. It is generally believed, however, that in most countries all over the world, there are only a small percentage of women in engineering and technological occupations. In fact, engineering at the higher education level has the lowest proportion of women students compared with other fields of study. This situation prompted the United Nations Education, Scientific and Cultural Organization (UNESCO) to adopt as one of its main areas of concern the elimination of discrimination based on sex and the full participation of women in the life of societies. Within this framework, UNESCO commissioned a study (Michel, 1988) on the common issues and problems that face the promotion of university level education and training of women, particularly in engineering.

The UNESCO study considered in depth a previous study on the general trends of participation of women in higher education (UNESCO, 1995) in order to put the question of women in engineering in its proper perspective. Despite the distinct trend towards parity between men and women in male and female enrolment in higher education, the quantum of participation of women is still relatively low and there are significant variations between country groups and between teaching disciplines *(Table 2.13).*

The data presented in *Tables 2.13* to *2.15* highlight some important facts:

- There is a wide regional variation in female participation in higher education, the rate being highest in Canada (51 percent) and lowest in Asia (29 percent).
- Although the participation rate for Africa is low (31 percent), the growth rate (10.2 percent) is the highest in the world.
- The disciplines of natural and exact sciences which include engineering and technology have the lowest participation rate of all disciplines, an order of 20 percent compared with social sciences (40 percent), the medical sciences (45 percent) and the pedagogical sciences (55 percent).
- The under-representation of women in scientific and technical disciplines (the exact and natural sciences) is virtually universal.

It is difficult to isolate statistics on engineering education from the UNESCO study. However, further detailed analysis of the UNESCO data and other available data by Michel (1988) reveal some important facts:

- The mean participation rate of women in science and technology (natural and exact sciences) enrolment in the five major regions covered by the study was between 16 and 24 percent.
- The comparative index of female participation in science and technology enrolment varied between 0.49 and 0.61 (compared with equal representation value of one) which means roughly that this sector has one-half fewer women than the rest of higher education.
- The mean participation index for science and technology based 24 countries covering all

Table 2.13: Growth Rate of Female Participation in Higher Education 1975-1982. (UNESCO, 1985)

Region	Average annual growth rate(%)		
	Total	Men	Women
All Countries	3.5	2.8	4.4
Industrialized Countries	1.7	0.6	2.9
Developing Countries	6.8	6.2	8.2

Table 2.14: Growth Rate of Female Enrolment in Higher Education by Region, 1975-1982 (UNESCO, 1985)

Region	Average annual growth rate (%)		
	Total	Men	Women
Europe	1.8	1.3	2.4
North America	1.6	0.2	3.5
South America	5.4	4.7	6.4
Africa (excluding South Africa)	9.0	8.6	10.1
Asia	6.0	5.3	7.4

Table 2.15: Female Participation in Higher Education Enrolment by Major Discipline Category and by Region, 1982/82 (UNESCO, 1985)

Region	Participation Rate (%)					
	Total	Education	Social	Medical	Agri-culture	Natural & Exact Sc.
Europe (excluding USSR)	45	69	52	55	34	24
Canada	51	71	54	73	32	21
Latin America	41	66	45	52	23	21
Africa	31	40	32	37	26	19
Asia	29	53	31	36	14	16
Oceania	45	68	49	56	25	22

regions is of the order of 0.52 with a range from 0.83 (Morocco) to 0.13 (Japan).

- Studies carried out by various researchers in over twenty countries (both industrialized and developing countries) have shown consistent under-representation of women in scientific and technical studies.
- Representation of women in technological studies is three times less than in the sciences for students entering higher education.
- Female students withdraw from engineering courses before graduation in greater numbers than from other courses of study (in particular the sciences).
- The engineering and technology sector has the lowest female representation of all higher education disciplines in most regions of the world.
- Studies conducted in European countries show significant differences in female participation between disciplines of engineering. The three main sectors of engineering - civil, electrical and electronic and mechanical which account for three-quarters of graduates have below average female participation rates compared with such other specialities such as materials science, chemical engineering and information technology.
- Data on women in higher education especially in engineering education are very scanty but there are strong indications that female participation is lower in the developing countries than in the industrialized countries due to various factors such as the effects of colonialism, tradition, culture or religion.
- Generally, female participation rates in the engineering professions after graduation are much below those in engineering education.

Although there are positive trends in female participation in engineering education all over the world, progress is slow. A recent situation report on the USA (Blaisdell and Cosgrove, 1993) showed that although there has been a dramatic increase in women representation in many professions over there past three decades, representation in engineering has remained low. LeBuffe (1994) in her annual survey of engineering enrolments and degrees for the Engineering Workforce of the American Association of Engineering Societies found that approxiamately16 percent of all bachelor degrees in engineering were awarded to women in 1993. In the same year, only nine percent of the doctoral degrees in engineering were awarded to women (Kerlin, 1995). Only seven percent of the engineering workforce in 1993 were women. In 1990, senior males in public high schools were more than three times as likely to choose a career in sciences, mathematics or engineering than women(NSF, 1994).

Reasons given in various studies for the low female participation in engineering education include:

- Misconception of engineering profession as a rough and dirty profession and an almost exclusively masculine field.
- Negative social view of women working as engineers.
- Cultural values, beliefs and practices, traditional and religious beliefs .
- Inadequate preparation at highschool level in mathematics, physics and chemistry.
- Low awareness of the bright career prospects in engineering and technology.
- Negative influence of parents, teachers and colleagues.

There is a strong, all-pervading, traditional, conservative belief among African parents, teachers and students that mathematics and science subjects are a male preserve. Parents in particular want their daughters to study subjects which are 'feminine' and which will enhance their marriage prospects. They perceive the study of mathematics and science as somehow likely to make their daughters 'abnormal' and not conducive to making them good wives (O'Connor, 1998). Many parents and teachers also believe that girls are inferior to boys academically and therefore often give less encouragement or, in fact, actively discourage them from science, mathematics and technology (SMT). Females in science and technology are regarded as women in man's world. In many countries, particularly in the developed countries, there are now local and regional initiatives which promote female technical education and encourage women to overcome the various formidable obstacles in undertaking engineering careers. Some countries have outlawed discrimination in education and employment on the basis of sex, introduction of special scholarship schemes, and awareness campaign about technological careers. Most countries in Africa are yet to start addressing the problem and there is clearly a dearth of reliable data on the scope and complexity.

Recent Studies on Engineering Education in Sub-Saharan Africa

There has been some effort to evaluate technical and vocational training programmes in Nigeria (Aina 1989; Atiomo 1989; Yebani 1992; Dubbey 1993; Ntim 1993; Koso-Thomas 1970, 1993; Nnebe 1995). University-level engineering education system which apparently has not been evaluated, is the focus of this study. The design focuses on comparative studies in two other Sub-Saharan Africa countries in order to identify common problems and possible areas of cooperation.

Chapter Three

Research Questions, Objectives and Hypothesis

Research Questions

Given the problems outlined above, the main research questions are: How relevant are the engineering curricula in selected African universities to the needs of developing economies? How well equipped are the products of the engineering training programmes to provide the necessary thrust for rapid industrial development, given the peculiar environment? What do employers think of them? Are the coherent government policies designed to enhance the provision of the right kind of engineering training required for rapid industrialization? What can be done to improve the on-the-job performance of engineers trained in African universities?

Research Objective

The main objective of the research is to evaluate the engineering education system in Nigeria and two other Sub-Saharan African countries with a view to determining the relevance to the processes of industrial development and technology capacity acquisition.

The specific objectives are to:

a) evaluate the systems of engineering education in three Sub-Saharan Africa countries- Nigeria, Ghana and Zimbabwe.
b) analyse the curricula in three countries and identify the deficiencies.
c) assess the capacity of the engineering training institutions for quality engineering education (funding, staffing, laboratory, workshop and library facilities, etc.)
d) assess the opinion of the end users of the products of engineering education on the education system and performance of the products on the job.
e) assess the adequacy and effectiveness of policies on engineering education in the three countries and determine policy initiatives that would be required to correct deficiencies in the engineering education system.

Research Hypothesis

i) Engineering education in the selected African countries does not adequately preparethe products for the acquisition of the invention, design and production capabilities.
ii) The capacity for training engineering students in the selected universities (funding, staffing, laboratories, workshops etc) is deficient.
iii) The existing curricula in the selected programmes do not promote the culture of entrepreneurship.
iv) Government policies for training engineers in the selected countries are inadequate.

Chapter Four

Research Design, Methods and Co-ordination of the Study

Geographical Coverage

The study was carried out in three sub-Saharan Africa countries, namely Nigeria, Ghana and Zimbabwe.

Basis of Selection of Countries

All the three countries selected were colonies of Britain and the universities had similar history of evolution. The main objective for selecting them was to compare the present structure of their engineering training programmes in order to assess the extent to which each has succeeded in adapting them to the peculiar needs of the economy. Ghana has only one faculty of engineering while Zimbabwe has only two, compared with 24 in Nigeria. The comparative study would facilitate an assessment of the effect of size of training facilities available in each country relative to the population. Zimbabwe has introduced some innovative engineering training techniques in the recent past (Appiah 1989). This study would enable the effects on the quality of the training program to be assessed and possible benefits to other African countries determined.

Scope of study

The study covered the following:

- Selected universities in the three countries.
- Selected engineering programmes in the universities.
- Policy bodies-government and professional in the three countries.
- Graduates of local engineering institutions and supervisors in the selected public and private sectors in companies and corporations in the three countries.

Data Sources

Data was collected from three main sources: (a) desk study: (b) detailed study of selected universities using questionnaires and in-depth interview guides, (c) in-depth interviews of policy makers and employers and graduates of engineering programmes currently in employment.

Desk Study

i) Publications of the selected universities, government supervisory bodies and professional bodies.
ii) Relevant published literature on training and employment of engineers.

Survey of Universities

i) Capacity study-collection of data on funding, staffing, laboratory and workshop facilities.
ii) Curriculum evaluation-detailed analysis of engineering curricula, evaluation of the opinion of the opinion of staff and students.
iii) In-depth interviews of principal officers, deans, academic and technical staff of selected universities.

Interviews of Policy-Makers and Employers

i) In-depth interviews of policy-makers in relevant ministries and parastatals.
ii) In-depth interviews of professional bodies responsible for the registration of engineers and control of the profession.
iii) In-depth interviews of employers in the public and private sectors.
iv) In-depth interviews of graduate engineers in employment.

Research Instruments

University Administrators and Engineering Faculty Staff

The research instruments comprised in-depth interview guides and were designed to obtain detailed information about funding of engineering programmes in the selected universities, the structure of the engineering curricula, staffing, available physical facilities, problems and future plans. University administrators, particularly deans were interviewed in depth to identify the problems of engineering education and obtain their views on solutions. Staff of engineering faculties preferably the heads of programmes were also interviewed to obtain their views on the curricula, staffing, laboratory, workshop facilities, classrooms, library facilities, their ability to update themselves on developments in engineering, students' attitude to their studies, linkages with industry etc. Their opinions on government policy on engineering education and suggestions on solutions to the problem of engineering education were also being obtained.

Engineering Students

The student questionnaire was designed to obtain the views of the senior students (Parts IV & V) on the curricula, adequacy of physical facilities and equipment for practical classes, practical contents of courses, quality of teaching, exposure to industrial atmosphere during training, and how they can relate their training to the demands of their future profession. Their suggestions were also sought on how to improve the quality of their training.

Employers of Engineering Labour

Information was sought from public and private sector employers of technical labour on the size of their establishment, specific nature of their business, the population of graduate engineers, sources and modalities for new and serving graduate engineers. Their opinion was also sought on the quality of graduates employed by them, their performance on the job, apparent deficiencies in their training and ways of improving their training in order to adequately prepare them for their future employment. As much as possible this questionnaire was administered to those who directly supervise these engineers.

Graduate Engineers

The study sought to find out how graduate engineers rate the relevance of their training to the demands of their employment and their suggestions on how the training programmes could be made more relevant. Interviewers also tried to find out details of their educational background, employment history, any additional training they may have undergone since graduation, their current responsibilities and any problems they may have encountered which may be traced back to deficiencies in their training.

Policy-Makers (Government and Professional Bodies)

The in-depth interviews of policy makers were focused on their assessment of current government policy on engineering education, policy deficiencies, and the quality of existing engineering training programmes, and their opinion on what needed to be done to improve the training of engineers. Information was collected on relevant activities of their establishments and their opinion was sought on the performance of graduate engineers on the job.

Sample Design

The selected sample for the study is presented in *Table 4.1* and *4.2*. The rationale for the sampling procedure is given below:

Basis for the Selection of Universities

Twenty four universities have engineering programmes in Nigeria compared with only one in Ghana and two in Zimbabwe. Ten universities were selected for study, comprising seven in Nigeria, one in Ghana and two in Zimbabwe. Four federal universities in Ife, Ibadan, Nsukka and Zaria were selected on the basis of geographical spread as well as the fact that they have the oldest faculties of engineering. The University of Ibadan was selected because it is one of the only two federal universities that offer a degree programme in petroleum engineering.

Table 4.1 (part I): Sampling Details and Administration of Student Questionnaires

Country	University	Programmes	Sample Size
Nigeria	Ahmadu Bello University, Zaria (Federal Government owned)	i)Mechanical Engineering ii) Civil Engineering iii) Electrical Engineering iv) Agricultural Engineering v) Metallurgical/Materials Eng.	50 (10/programme) (Parts IV &V)
Nigeria	University of Nigeria, Nsukka (Federal Government owned)	i) Mechanical Engineering ii) Civil Engineering iii) Electrical Engineering iv) Agricultural Engineering v) Electronic Engineering	50 (10/programme) (Parts IV &V)
Nigeria	Obafemi Awolowo University, Ile-Ife (Federal Government owned)	i) Mechanical Engineering ii) Civil Engineering iii) Electronic/Electrical Eng. iv) Agricultural Engineering v) Metallurgical/Materials Eng. (vi) Chemical Engineering vii) Computer Engineering	70 (10/programme) (Parts IV &V)
Nigeria	University of Ibadan (Federal Government owned	i) Mechanical Engineering ii) Civil Engineering iii) Electrical Engineering iv) Agricultural Engineering v) Petroleum Engineering	50 (10/programme) (Parts IV &V)
Nigeria	Federal University of Technology Minna	i) Mechanical Engineering ii) Civil Engineering ii)Electrical/Electronic/ Computer Engineering iv) Agricultural Engineering v) Chemical Engineering	50 (10/programme) (Parts IV &V)
Nigeria	Federal university of Technology, Akure	i) Mechanical Engineering ii) Electrical/Electronic Eng. iii)Civil Engineering iv) Agricultural Engineering v) Metallurgical/Materials Eng vi) Mining Engineering	60 (10/programme) (Parts IV &V)

Table 4.1 (part II): Sampling Details and Administration of Student Questionnaires

Country	University	Programmes	Sample Size
Nigeria	Ladoke Akintola University of Technology Ogbomoso (State Government owned)	i) Mechanical Engineering ii) Civil Engineering iii) Electrical/Electronic Eng. iv) Chemical Engineering v) Computer Engineering	50 (10/programme) (Parts IV &V)
Ghana	University of Technology, Kumasi, Ghana, (Government owned)	i) Mechanical Engineering ii) Civil Engineering (Government owned) iii) Electrical/Electronic Eng. iv) Agricultural Engineering v) Chemical Engineering vi) Geodetic Engineering vii) Mining Engineering viii) Mineral Engineering ix) Geological Engineering	90 (10/programme) (Parts IV &V)
Zimbabwe	University of Zimbabwe, Harare Government owned)	i) Mechanical Engineering ii) Civil Engineering iii) Electrical Engineering iv) Agricultural Engineering v) Mining Engineering vi) Metallurgical Engineering	60 (10/programme) (Parts IV &V)
Zimbabwe	University of Technology, Bulawayo (Government owned)	i) Electrical Engineering ii) Electronic Engineering iii) Water Engineering	30 10/programme) (Parts IV&V)
	Total =	**56 Programmes**	**560 Respondents**

The Federal Universities of Technology, Akure and Minna, were selected as two of the four federal universities of technology while Ladoke Akintola University, Ogbomoso, was elected because it is a university of technology as well as a state university. The basis for selection of the Nigerian universities are:

i) Age of the engineering faculties
ii) Geographical spread
iii) Range of engineering programmes

iv) Type of university; regular university or university of Technology
v) Ownership federal or state ownership

Table 4.2: In-depth Interviews (All selected universities and countries)

S/N	Respondents	Details of Selection Sample Size	
1	Vice-Chancellors of Universities	The VC of each of the ten selected universities was interviewed	10
2	Bursars		10
3	Librarians		10
4	Deans of engineering faculties		10
5	Academic staff of engineering faculties	1/ engineering programme	56
6	Technical Staff	1/engineering programme	56
7	Employer (Public Sector)	5/country	15
8	Employer (Private Sector)	5/country	15
9	Graduate Engineer (Public Sector)	10/country (2 from each of the establishments selected for 7 & 8)	30
10	Graduate Engineer (Private Sector)	ditto	30
11	Education Ministry/Parastatal	Government body responsible for Policy on University Education (1/country)	3
12	Engineering profession regulating body	Registration body/professional society (1 country)	3
13	Student Industrial Experience Supervisory body	(1/country)	3
		TOTAL =	**251**

Selection of Engineering Programmes

The basic engineering programmes were selected (mechanical, civil and electrical engineering). All the selected universities offer these programmes. Other programmes which are unique to some of the universities were also selected; electronic, computer, chemical, water, mining, metallurgical engineering etc.

Selection of Respondents

All target groups are selected purposively. The student questionnaire was administered to a sample of students in the last two years of the programme. This was because most programmes concentrate mainly on basic science and basic engineering courses in the first three years and most students do not start to understand what engineering is all about till the fourth year. The selection of employers covered a wide range of engineering practices and the employers selected for inter¡view were those who supervise the work of engineers. Graduate engineers interviewed were also selected from the establishment of the employers interviewed.

Coordination of the Study

Each country had a coordinator who was responsible for the training of research personnel in this country and the collection of data. Three coordination meetings were held already in Kumasi (Ghana), Harare (Zimbabwe) and Ile-Ife, (Nigeria) respectively. The first meeting was held to plan the research and pre-test the instruments. The second meeting in Harare was held to review progress and evaluate data collected so far. The third meeting took place in Nigeria to analyse the data and finalize the report.

Chapter Five

Country Report - Nigeria

Introduction

Nigeria is situated in West Africa and is the most populous nation in Africa, with an estimated population of about 120 million. Nigeria was a British colony prior to 1960 when it became independent. Two years later, it became a republic. In 1960, the country comprised three regions Eastern, Western and Northern Regions, but has been progressively restructured over the years to its present 36 states, with the capital in Abuja. For a long time since independence, Nigeria was ruled by a military government except for the two brief periods of four years each. It recently held an election through which a civilian government was formed.

Education System in Nigeria

Prior to 1956, Nigeria had a uniform education system comprising ten years in primary school, five years in the secondary school, two years in higher school and three to six years in the university depending on the course. Those who passed the university entrance examination after secondary school proceeded to the preliminary year of the university and then spent three to six more years. In 1956, the old Western Region introduced the Universal Free Primary Education system which shortened the period in primary school to six years. The current 6-3-3-4 system was introduced for the whole country in 1977.

Education is on the concurrent list of 1979 constitution and both the Federal and State Governments can establish schools at any level. However, the Federal Government is only involved at the secondary and tertiary levels and has also established regulatory bodies at all levels.

Prior to independence in 1960, the only notable development in the field of technical education was the establishment of Yaba Technical Institute (now Yaba College of Technology) in Lagos in 1948 and Technical Institute, Kaduna (now Kaduna Polytechnic in 1958).

The period 1960-69 witnessed the establishment of technical secondary schools and trade schools by Federal and State Governments throughout the federation. There are presently 105 technical colleges and trade ceases and 43 polytechnics and colleges of technology. In the same period, four universities in the country introduced courses in engineering and technology. The next decade witnessed a rapid development of technical education. Federal and State polytechnics were established in many parts of the federation and five federal universities of technology were also established. Technical courses were introduced in most of the existing conventional universities and 25 of the 36 federal and state universities now offer engineering and technology courses.

All universities in Nigeria have adopted the two-semester, course-unit system and students spend a minimum of four, five or six years, depending on the course. In order to be eligible for admission in to any of the universities, students are required to have passed at credit level in at least five subjects, including English language in the Senior Secondary School Certificate or General Certificate Ordinary Level examination. In addition, candidates must have passed at the Joint Matriculation Examination (JME) conducted annually by the Joint Admission and Matriculation Board, (JAMB). Candidates who have passed the General Certificate Examinations at the advanced level do not take the JME examination and are considered for admission to the second year.

Engineering Education in Nigeria

The University of Nigeria, Nsukka, established in 1960, was the first to have an engineering faculty, followed by Ahmadu Bello University, Zaria, and the University of Lagos, both of which were established in 1962. There are now 26 out of a total 36 universities in Nigeria offering engineering courses. (Table 5.1). The programmes offer five years B.Sc. Honours, B. Eng. or B.Tech. degrees. The range of programmes offered include the traditional engineering courses; civil, mechanical and electrical engineering as well as electronic, computer, chemical, agricultural, petroleum and petrochemical metallurgical and materials, mining and food engineering. All the programmes have a similar structure comprising a first (preliminary) year of basic science courses, followed by two years of basic engineering courses and two years of courses specific to each area of specialization. Students who already have the General Certificate of Education at advanced are exempt from the preliminary year. Students are also required to spend at least two long vacation periods and one full semester in the fourth year in industry or other relevant employment in order to acquire practical experience. Each student is also required to carry out an independent experimental or design project in the final year.

National Policy on Technical/Engineering Education

The first National Policy on Education adopted by the Federal Government of Nigeria in 1977 introduced universal free primary education and a uniform 6-3-3-4 education system in Nigeria. The system involves a uniform six years primary school education followed by a three year junior secondary school certificate (JSS) and a three year senior secondary school certificate (SSC) respectively. The last stage comprises a four year university education (minimum). At the JSS level students would be introduced to some technical subjects. Depending on their ability, those who are strong academically would proceed to the Senior Secondary School (SSC) stage and ultimately to university while the others would be given vocational training and may ultimately proceed to polytechnics. The policy statement also contained far-reaching proposals on technical education which included:

- Training of technical teachers for science, technology and vocational training programmes at the primary, secondary and tertiary levels.
- Introduction of elementary technology into the school curriculum as early as possible.
- Introduction of skill-forming technical courses into the secondary school curriculum.
- Restructuring of the curricula in technical schools to broaden the scope and focus on national needs particularly in food processing and preservation, clothing manufacture, and maintenance technology.
- Establishment of multi-purpose vocational centres and technical schools in every local government area.
- Teaching of science and technology in an integrated manner in schools to promote appreciation by students of the practical implications of basic ideas.
- Provision of well-equipped workshops for junior secondary schools and technical colleges.
- Establishment of multi-purpose vocational centres, colleges of technology and polytechnics, with curricula which emphasise hands-on training.

The National Science and Technology Policy adopted in 1986 included the following proposals on technical and engineering education:

- Increase in the admission ratio of science-based students to non- science courses in universities and other tertiary institutions.
- Adequate funding of science-based courses and provision of laboratory equipment.
- Provision for intensive practical courses and industrial training as part of the course curricula in technical colleges and universities.

As far as could be ascertained, the policy statements were not based on any rational demand-supply data. There has been no systematic study to determine the current and future projections of the demand for engineers and technologists in terms of numbers and mix. The fact that both the Federal and State governments are free to set up technical training institutions has led to an unbridled proliferation of ill-equipped colleges of technology and faculties of engineering in many universities, all of which, with the exception of a private college of technology, are funded either directly by the Federal Government or by State Government from allocations received from Federal Government.

Assessment of Policy on Technical Education

The nation was apparently ill-prepared for the 6-3-3-4 and UPE schemes. The sudden and very large increase in student population created a major financial burden on both the Federal and State Governments; infrastructures have remained grossly under-developed; the drop-out rate from the UPE scheme has as high as 86 percent in the rural areas (Yoloye et al, 1993), the dilemma remains on what to do with about 62 percent of the primary school leavers for whom primary school is terminal. Because of inadequate instructional materials and facilities, instructional strategies tend to be predominantly lecture, thus limiting severely exposure to practical classes, especially in the sciences, with an inevitable, negative effect on the quality of students admitted to technological and engineering course at the tertiary level. Students, teachers, graduates, employers, supervisors and policy makers were asked to assess the existing policy on engineering education and suggest improvements. Their responses are presented below.

Assessment by Students

Only 3.3 percent of the 215 students interviewed thought that the existing technical education policy and system is excellent. About 82 percent rated it from fair to very good while only about 11 percent rated it from poor to very poor. Suggestions for improvement included provision for more practical classes, provision of laboratory equipment, library books and infrastructure, recruitment of more teaching staff, and greater involvement of the private sector in funding. The pace of technological development is usually a good measure of the effectiveness of policy. Only about 19 percent of the students rated the pace in the country from good to excellent while the others rated it from fair to very poor.

Reasons given for poor rating included slow pace of industrialization, heavy dependence on importation which was considered detrimental to technological development, poor funding of technological education, poor training facilities and poor encouragement for entrepreneurship.

Assessment of policy by Graduates

Most of the graduates interviewed thought that the existing policy on technological education is good with 84.3 percent, rating it from good to excellent. However, most (91.6 percent) felt that government had not done enough to actualize the policy. Their main complaint was that there seemed to be little or no relationship between the types of technologists and engineers being trained and the needs of the employment industry, since most found it difficult to secure employment . About 80 percent of the students rated the pace of technological development in the country from fair to very poor. The main reasons given were the relegation of technology development to the background in fund allocation. There were no visible efforts to develop the manufacturing sector of the economy or to rescue the few existing companies from collapsing.

Assessment of the policy by Teachers and Trainees

Over 98 percent of the teachers and trainers interviewed were aware of government policy on technological education but only 8.2 percent had any input policy issues mainly through curriculum development and evaluation for accreditation. Suggestions for improvement included the development of policies to make graduates creators rather than seekers of employment, better motivation of trainers in terms of conditions of service and access to further training, particularly in industry. They also felt that technological education should be given priority in terms of funding.

Assessment of Policy by Employers

None of the employers interviewed had been involved in policy formulation on technological education or development. All of them were of the opinion that they should be involved since they are the ultimate end users of the products. However, the majority (82.7 percent) were satisfied with the quality of graduates in their employment. They had good theoretical grounding and, although they were deficient in exposure to practical aspects, they generally respond well to further training and quickly overcome their initial handicaps. Among suggestions for policy improvement, employers feel that they should be consulted in articulating government policies on technological education and it should be mandatory for technological training institutions to have representatives of employers on their academic boards. Employers also feel that teachers should be given practical exposure by encouraging them to spend periods in industry.

Assessment of Policy by Policy-Makers

The policy makers interviewed included key staff of the Federal Ministry of Education, Federal Ministry of Sciences and Technology, National Universities Commission, Federal Ministry of National Planning, National Manpower Board, The Council of Registered Engineers, and the Industrial Training Fund. All of them had not been involved in either policy formulation, execution or both. Their rating of the achievement of the policy objectives is summarized in *Table 5.2.* It is clear from the ratings that the policy-makers admitted that the provisions of the policy had not been articulated and the main objective had not been achieved. It is also clear from the responses presented in *Table 8.3* that the policy makers had no reliable baseline data on which any meaningful policy formulation or execution could be based.

All the policy makers interviewed stressed the urgent need for a comprehensive study to establish the current status and future projections of technological manpower needs of the country, which is a prerequisite for any meaningful planning and policy formulation.

The professional bodies complained of too little involvement in policy formulation, considering the fact that monitoring and regulation of professional practice was one of their main duties. They recommended greater involvement at the policy formulation stage. They also expressed the view that a comprehensive review of the national policy on technological education is long overdue and should involve employers as well as professional bodies.

Most of the policy-makers interviewed (90 percent) believed that the lack of industrial experience of the average technical teacher is a major handicap to performance and there should be a deliberate government policy on the continuing education of technical teachers, funded jointly by government and employers.

Table 5.1: Assessment of Achievement of Policy on Technological Education by Policy Makers

Objectives	Exce-llent	Very Good	Good	Fair	Poor	Very Poor
Training of technical teachers	-	-	-	42	58	-
Early introduction of elementary technology in the school system	-	-	-	34	47	19
Introduction of skill-farming technical courses into the secondary school curriculum.			7	56	35	2
Restructuring of technical curriculum to broaden the scope and focus on national needs.				43	51	6
Establishing multi-purpose vocational and technical school in every local Government.				7	59	34
Teaching of science and technology in an integrated manner to promote appreciation by students of the practical implications.		3	32	41	24	
Provision of well-equipped workshops for junior secondary schools and technical colleges					67	33

Table 5.2: Availability of Planning Statistics on Technical Education

Area	Yes	No
Current population and mix of technical manpower in the country	-	100
Projections of the country's technical manpower	-	100
Existing technical training establishments	39	61
Projections of future requirements of technical training establishments	-	100

Resource Capacity for Engineering Education in Nigeria

Tertiary institutions in Nigeria can be grouped into three categories: those funded by the Federal Government, those funded by State governments and Private Institutions. Nearly all technical institutions fall in the first two categories and only one polytechnic is privately funded. Since State governments receive most of their funds from the Federal government, it can be concluded that the Federal government is directly or indirectly responsible for funding of technical institutions although some are administratively under the control of State Governments. Twenty of the Federal universities and six of the twelve State Universities offer engineering courses.

Financing of Engineering Education

The primary source of funding of all universities in Nigeria is the Federal government, directly or through State governments. Tuition is free in Federal Universities but most generate minor additional funds from internal sources. None of the universities has been able to meet the National Universities Commission guidelines of generating at least 10 percent of the funds received from the Federal government. The capacity of the universities to generate funds from any other source is insignificant.

Table 5.4 shows details of funding level for 1987/88 and 1933/94 sessions for the 21 Federal universities funded through the National Universities Commission. (The three Federal universities of agriculture are funded through the Federal Ministry of Agriculture).

Although the level of funding increased by a factor of over 30 during this period, the purchasing power of the funds reduced considerably due to the massive devaluation of the local currency by a factor of about 20. In the same period, student enrolment nearly doubled. The effect of the major drop in the value of the naira was particularly devastating since most of the teaching and research equipment and spare parts, library acquisitions, are obtained from foreign sources. The exponential growth in student population without commensurate increase in funding has also been a major problem for the universities. The level of funding per student dropped from US $ 1,1791 in 1987 to $ 214 in 1994.

Table 5.3: Funding of Federal Universities in Nigeria

Fund	1987/88	1993/94	% Increase
Recurrent (N million)	467.5	27,787	594
Capital (N million)	60.8	800	1,320
Naira equivalent of US$	4.29	80	1,765

The actual cost of training per student varies significantly between universities, depending on location, student population, staff-student ratio, and courses offered as shown in *Table 5.5.* It is clear from the table that there is no policy of preferential funding for any discipline. In fact, each university decides on the allocation of its recurrent expenditure, depending on its own priorities. The only condition stipulated by the National Universities commission is that 10 percent of funds received from the commission must be expended on the University Library. For example, the University of Maiduguri spends about eight times the amount that Nsukka spends in the training of each engineer or technologist.

The bulk of the recurrent fund allocation to each university is expended on staff emoluments as shown in *Table 5.6*. Taking into account the statutory 10 percent allocation to university libraries, most universities have less than 15 percent left for various other items of recurrent expenditure, including utilities, insurance, security, maintenance of facilities. Inevitably, there is usually only about five percent or less for academic activities. The problem has been compounded by government regulation of fees payable by students. For example, Federal Universities are only allowed to charge N 90 per student per bed per session, less than the cost of replacing of an electric bulb. Also, most student halls are heavily congested, with most accommodating more than twice the design capacity, hence the cost of maintenance of the facilities is usually high.

The recurrent expenditure profile of one of the first generation universities in the 1996/97 session is shown in *Table 5.6.* Less than 10 percent of the fund was allocated to academic activities such as teaching supplies and expenses, laboratory consumables, fieldwork expenses, examinations, postgraduate supervision, attendance of learned conferences, funding of sabbatical leave, and staff development.

All the vice-chancellors interviewed cited poor funding as the most serious problem they have to contend with and they spend so much time in working out survival strategies that there is little time for development planning. They also claimed that most of the problems with students and staff were results of under-funding. The situation is so bad that most universities are unable to pay their electricity bills which have accumulated to the equivalent to the total recurrent grant for three months in some cases.

Landscape
table

Table 5.5: Percentage of Recurrent Expenditure Committed to Staff Emoluments in some Nigerian Universities in 1992/93 Session

University	% Recurrent Fund Spent on Staff Emoluments
University of Ibadan	68.5
University of Lagos	70.4
University of Nigerian, Nsukka	76.0
ABU, Zaria	75.9
OAU, Ife	67.9
University of Maiduguri	67.0
University of Sokoto	72.2

Source: National Universities Commission

All the policy makers interviewed agreed that the level of funding of universities was grossly inadequate but stressed that it had to be related to the other equally important sectors of the economy such as basic primary education, health, and infrastructural development. They also identified the current, unregulated growth of the university system as a reason for the inadequacy of funds. Some of them questioned the expediency of establishing twenty six poorly staffed, poorly equipped departments of mechanical engineering in the country, for example, especially when the economy did not seem to be able to absorb the bulk of the products. They agreed that there was no data on the current and future needs of the country in terms of technical manpower and stressed the view that this problem had to be solved before any meaningful policy on technological education could be evolved.

The university administrators and other policy makers also suggested the involvement of parents in the funding of university education through the introduction of tuition fees as the only way out of the financial predicament of most universities. They also wanted the deregulation of other fees such as hostel accommodation. One vice-chancellor claimed that the total income from bed space fees in one year was not enough to maintain the hostels in one month. The proposal for

Table 5.6: Allocation of Recurrent funds by one of Nigeria's first generation universities in 1996/97 session

Expenditure	% of Recurrent
Salaries and emoluments	74.8
General expenditure (Administration)	7.3
Contractual obligations	11.3
Academic expenditure	6.6
Total	100

Source: National Universities Commission Monitoring Obafemi Awolowo University introduction of tuition fees and deregulation of other fees was part of the recommendations of the committee on the university system as well as vision 2010 being considered by the Federal government.

Student Enrolment

There has been a phenomenal growth in both the number of universities and student enrolment in Nigeria in the past 20 years or so. In 1976, there were only six Federal Universities and no State Universities, compared with the current twenty four Federal and twelve State Universities. The student population has also grown in the same period by a factor of six to about 350,000.

In 1988, students enrolled in science-based courses constituted only 27.9 percent of the total student population in the Federal universities. The enrolment in engineering and technology discipline increased slightly from 7.1 percent of total enrolment in federal funded universities in 1988, to 9.7 percent in 1994 (*Table 5.7)*. The low ratio of science to non-science students prompted the NUC to introduce a target of 60 percent science-based student enrolment, which all the Federal universities were required to meet. Financial incentives were also introduced for universities which comply. This has had a very positive effect. *Table 5.8* shows the individuals ratios for the sixteen conventional federal universities. Some individual universities had actually attained the National Policy stipulation *(Table 5.9).* The ratio of science-based to non-science courses for the State Universities is considerably lower than for the Federal Universities between 45 percent and 50 percent. Only six of the twelve State Universities offer engineering courses.

The total annual admission to all universities in Nigeria is about 100,000 representing only about 20 percent of applicants, and an annual growth rate of total enrolment of between 7.5 percent and 10 percent. The universities are under increasing pressure to increase admission quota in view of the very large pool of qualified candidates who are largely unemployable. However, there has been no matching development of infrastructure, particularly hostel accommodation. One of the Federal Universities which had about 22,000 enrolled students had accommodation designed for only 8,500 students. Since there was no rentable accommodation in the vicinity of the location of the university, the other students were forced to squat and rooms designs for four students were occupied by ten to twelve students.

Table 5.7: Enrolment in Engineering and Technology Courses in Federally-Funded Universities in Nigeria

Enrolment in Engineering and Technology		% of Total Enrolment	
1988	1994	1988	1994
11,914	22,080	7.1	9.7

Source: NUC Annual Reports, 1988, 1994

Table 5.8: Science: Non-Science Ratios for sixteen Conventional Federal Universities in the 1994/95 session

Universities	Science /Non-Science Ratio
Ibadan	66:34
Lagos	52:48
Nsukka	57:43
Zaria	62:38
Ife	66:34
Benin	65:35
Jos	40:60
Calabar	57:43
Kano	53:47
Maiduguri	47:53
Sokoto	40:60
Ilorin	57:43
Port Harcourt	56:44
Uyo	39:61
Awka	47:53
Abuja	30:70

Teaching Support Staff

The phenomenal growth in student population has not been matched by a similar growth in academic staff population. In the 1987/88 session the total enrolment in Nigeria's 20 Federal universities was 123,234 while there were 9,216 academic staff (*Table 5.9*), a student:staff ratio of 1:13.4, already 10 percent below the National Universities Commission (NUC) guidelines. By 1994, the number of Federal Universities has increased to 24, the student enrolment has increased by 85 percent while the academic staff population increased by only 19.7 percent.

The harsh economic situation in the country has also prompted many academic staff to seek better employment abroad. The highest paid professor in the university system earned the equivalent of about US$100 a month in 1997. His total annual salary could not pay for three journal subscriptions. There has also been a high level of staff movement from the older universities to higher status levels in the newer universities. In engineering and technology, the student-staff ratio was 1:21 in 1994, compared with NUC guideline of 1:9 (*Table 5.10*). In effect, less than half of the required staff was on ground. The situation has worsened since then because recruitment has been stunted and more staff have moved to greener pastures, particularly the more prosperous African countries.

Table 5.9: Number of Enrolled Students and Academic Staff in Federally-Funded Nigerian Universities

	1987/88	1993/94	% Increase
Enrolled Students	123,234	227,999	85
Academic Staff	9,216	11,027	19.7
No.of University (Federal)	20	22	

In recent study on staff retention in African tertiary institutions (Blair and Jordan, 1994), Nigeria compared very poorly with such other African countries as South Africa, Botswana, Zimbabwe and Ghana in terms of staff welfare and remuneration. This was considered a major reason for the high turnover among academic staff, especially in those areas of specialization which are in demand in the other countries.

The situation of technical support staff is much better compared with academic staff. There are many polytechnics in the country training technical personnel and several of the older universities also have technical staff training programmes.

Prior to the economic downturn of the late 1980s, most of the older universities had staff development programmes which included recruiting their best students as graduate assistants and sending them to train in foreign institutions. Such programmes can no longer be sustained and most of

Table 5.10: Recommended and Actual Staff-Student Ratios by Disciplines in Federally- Owned Nigerian Universities

Discipline	Universities Actual	NUC Guidelines
Administration	1:45	1:20
Agriculture	1:13	1:9
Arts	1:16	1:20
Education	1:29	1:24
Engineering	1:21	1:9
Env Design	1:17	1:10
Law	1:30	1:2o
Medicine	1:10	1:6
Pharmacy	1:14	1:10
Sciences	1:15	1:10
Social Sciences	1:21	1:20
Vet. Medicine	1:7	1:6

Source: National Universities Commission

Table 5.11: Postgraduate Enrolment in Federally-Funded Nigerian Universities

1988			1995		
PG	Total	% of Total	PG	Total	%of Total
30,974	123,234	25.1	19,938	227,999	8.7

those who were abroad at the onset of the depression never returned. The postgraduate programmes in the Nigerian universities which had been a major source of recruitment of academic staff since the foreign training programmes ceased have also been adversely affected by the downturn in the economy. The remuneration in the university system has become so unattractive compared with the private sector rather that most of the brilliant students prefer to take up employment in the private sector rather than register on a postgraduate programme. In the 1987/88 session the postgraduate enrolment was 25.1 percent of the total student enrolment. This has dropped to only 7.6 percent in 1995 *(Table 5.11)* and is probably less than 5 percent in most universities currently. Furthermore, the quality of the intake has dropped drastically because of the better attraction by the private sector for the good graduate.One of the vice-chancellors interviewed recently announced at the last university convocation ceremony that all students who had first class degree were offered automatic appointment as Graduate Assistants and scholarship for postgraduate studies. Not a single one of the over thirty qualified graduates took up the offer.

Teaching, Laboratory, Workshop and Library Facilities

Although funding increased by a factor of about of about ten in the same period, the value of the naira compared with the US$ had dropped by a factor of about 20. *(Table 5.3).* Since most of the equipment and library requirements of the universities are obtained from foreign sources, the drastic drop in the value of the local currency has a devastating effect on the state of teaching and research facilities. New equipment can no longer be purchased and spare parts for the existing ones are no longer available either because foreign exchange is not available or the models have been phased out. The younger universities have been particularly badly affected and some have resorted to transporting their students to the older universities for practical classes, particularly in engineering.

Classrooms in most universities are inadequate and have dilapidated furniture. Teaching aids are virtually non-existent. Classes have to be scheduled for odd hours and quite often, classrooms are too small to accommodate large classes.

The drastic drop in the value of the local currency has had a particularly severe effect on the university libraries, which could no longer import books and journals. One of the first generation universities which previously subscribed to nearly 6,000 journals in 1986 at a cost of N 0.8M could only sustain about 50 titles in 1996. As a result of the recent World Bank loan secured by the Federal Government of Nigeria for the revitalization of the Federal Universities, the library was able to increase subscription to 196 titles in 1997 at a cost of N29.1M. The World Bank loan also enabled some universities to acquire some equipment and assist some teaching staff registered for higher degrees in Nigerian Universities to spend short periods in laboratories abroad to carry out aspects of their research for which equipment was not available locally. However, many of them did not return at the expiry of their approved stay. The programme also lasted for only two years, hence the impact on the precarious situation of teaching facilities was minimal.

In 1997, the National Universities Commission organized a centralized purchase of laboratory equipment and library books and journals for federally funded universities. About 50 percent of the teaching and research equipment vote for participating universities was pooled and changed to foreign currency at the preferential rate N22 to the U.S Dollar, compared with N85 in the autonomous market. The orders are being delivered currently and some improvement in the facilities is expected.

Student Industrial Work Experience

Most engineering programmes in Nigeria have always had an industrial training component which requires students to spend at least two long vacation periods in industry during their training. Faculty staff visit students during the industrial training periods to monitor their progress and industry-based supervisors are required to assess the performance of each student. Each student is also required to write a report which is assessed. No student can graduate without completing the industrial training successfully. The scheme was largely unsuccessful initially because most employers did not accept students and most of those who did merely paid the students without having any coherent training plan for them.

In order to correct this anomaly, the Federal Government of Nigeria promulgated a decree in 1971 establishing an Industrial Training Fund (ITF) (Decree 47) to which employers must contribute three percent of their payroll or 1/2 percent of their turnover, whichever is greater. This main assignment of ITF is to manage the Student Industrial Work Experience Scheme (SIWES) which is designed to give adequate practical and industrial exposure to engineering and technical students during their education. An organizational structure was set up to manage the fund and finance student placement efforts by faculty staff as well as pay the students during training. The decree was amended in 1973 and 1975, the latter of which reduced the statutory contribution to one percent of the yearly payroll.

The decree was amended again in 1990 (Decree 44), making it mandatory for industries to accept students. The ITF compiles lists of employers and available training places for industrial attachment and forwards to the National Universities Commission and coordinating agencies. The tertiary institutions are required to establish SIWES Coordinating Units headed by industrial coordinators who organize the placement of the students as well as the supervision by faculty staff. The scheme has been extended to polytechnics, colleges of education, applied science programmes and secondary school students on technical and vocational courses.

The ITF also organizes training courses for trainers in industry, SIWES coordinators at the institutions as well as the coordinating agencies The National Universities Commission (NUC), the National Board for Technical Education (NBTE) and the National Commission for Colleges for Education (NCCE), all of which have SIWES coordinating units.

The SIWES scheme has been having difficulties lately, due to the exponential increase in student population over 75,000 students were to be placed in 1997. With the downturn in the economy, many industries have closed down and most of those still operating are working at a fraction of the installed capacity (in many cases below 10 percent). The number of industries which are still able and willing to accept students has dwindled significantly therefore.

Another problem with the ITF programme is the non-provision of industrial training for staff of engineering and technical faculties. Most of them have no industrial experience and many have never even visited any industry. It would greatly enhance the effectiveness of the scheme if staff could be sponsored to spend periods in industry. ITF should also sponsor student and staff excursions to industry as well as industry-engineering faculty seminars on relevant topics.

Assessment of Resource Capacity for Engineering Education

Students, staff and graduates were requested to fill in questionnaires on their opinion on resource capacity for engineering education. University vice-chancellors, bursars, librarians, and deans of faculties, employers and supervisors, government policy makers and professional bodies were also interviewed in depth to find out their opinion and suggestions.

Assessment by Students

Only 26 percent of the students who were satisfied with the way they were being trained. The deficiencies identified include inadequate exposure to practical work (57.9 percent), poor training facilities (30.0 percent). When asked specifically about adequacy of resource capacity for their education *(Table 5.12),* most of them rated the components except funding from fair to excellent.

Assessment by Teachers and Trainers

The results of the questionnaire interview of academic teachers and trainers showed that a large majority of them (75.4 percent) took up employment out of interest. None of the respondents mentioned monetary reward as motivation and only 4.9 percent listed job security as the main motivation. Most of them were well qualified and 85.8 percent had at least a Master's degree. Most of them (77 percent) claimed to have had industrial experience prior to taking up employment. However, in-depth interviews of deans of faculties showed that the claims were not correct as most were on their first jobs ever. It was clear from the results that the majority of staff were relatively inexperienced and about 74 percent had been on the job for 15 years or less. Only 8.2 percent had spent over 25 years. In-depth interviews also revealed that industrial experience was limited in most cases to the student industrial attachment experience. Less than 10 percent had actually ever worked in any industry. The majority of staff interviewed (75.4 percent) rated the teaching staff complement from fair to excellent while 78.7 percent rated the technical staff support from fair to excellent. Also,

Table 5.12: Opinion of Students on Resource for Engineering Education

Resource Capacity	Rating %					
	Excellent	V. Good	Good	Fair	Poor	V. Poor
Performance of teachers/trainers	11.6	32.1	39.5	12.1	1.9	2.8
Availability of study materials	1.4	5.6	26.5	46.0	20.5	-
Availability of equipment	1.4	5.6	18.6	42.8	31.6	-
Availability of teachers/instructors	5.1	20.5	40.9	27.4	6.0	-
Availability of classrooms	15.8	21.4	25.1	27.4	10.2	-
Availability of funding	3.3	5.1	12.1	24.7	53.5	1.4
Availability of technical books and journals	6.0	13.5	23.3	29.3	27.9	-
Effective use of study materials	1.9	18.1	42.3	26.5	10.2	0.9
Effective use of equipment	0.9	7.0	30.2	37.2	24.7	-
Effective use of teachers/trainers	7.9	25.1	40.0	19.1	7.0	0.9

deans of faculties interviewed warned that, while the overall picture with the respect to academic staff may be fairly good, the situation varied widely between areas of specialization. For example, most of the deans estimated that over half of the staff establishment positions in courses such as computer engineering, electronic and electrical engineering and petroleum engineering had remained unfilled for many years. Most had little problem filling technical positions.

Table 5.13: Assessment of Resource Capacity for Engineering Education by Teachers and Trainers

	Rating %					
Resource Capacity	Excellent	V. Good	Good	Fair	Poor	V. Poor
Teaching materials	-	5.6	22.2	40.7	27.8	3.7
Laboratory facilities	-	1.9	13.0	35.2	40.6	9.3
Workshop equipment	-	5.6	22.2	35.2	25.9	11.1
Library facilities	1.9	9.3	20.4	44.4	18.5	5.5
Teaching/staff/instructors	9.3	22.2	40.7	13.0	9.3	5.6
Technical support staff	5.6	24.1	31.5	27.8	9.3	1.8

Over 85 percent of the staff rated the laboratory facilities from fair to very poor (*Table 5.13)*. In response to in-depth interviews, they complained that most of the available equipment was either obsolete or non-functional and funds were not available for the purchase of chemicals most of which are imported. They gave similar rating to workshop equipment (72.2 percent) teaching materials (72.2 percent), and library facilities (68.4 percent). However, the majority (72.2 percent) rated the availability of teaching staff from good to excellent. The availability of technical support staff was also similarly rated (61.2 percent).

Assessment by Graduates

Over half (52.1 percent) of the graduates interviewed rated the availability of study materials from good to excellent. Availability of classrooms, technical books and teachers and instructors were also well rated (91.2 percent, 69.6 percent and 77 percent respectively, *Table 5.14*). However, only 39 percent of the respondents thought that the equipment was good. The majority of the graduates also assessed that students were making good to excellent use of the available capacity. Effective use of teachers and instructors, technical books, equipment and study materials were rated at least good by (87 percent, 69.6 percent, 82.5 percent and 91.3 percent respectively). However, over half (56.5 percent) rated funding from fair to poor.

Assessment by Employers and Supervisors

Employers were aware of the inadequacy of training resources in most engineering institutions in the country and the need for improved funding. However, none of those interviewed had ever contributed any resources in terms of books, equipment, endowed chairs, etc. to any engineering institution. Some claimed that, since they pay education and Student Industrial Work Experience Scheme (SIWES) taxes, they saw no need for any further contribution. Others claimed that they had never received any request and would probably assist if they did.

Table 5.14: Evaluation by Graduates of Capacity in Engineering Education

Area	Rating %					
	Excellent	V. Good	Good	Fair	Poor	V. Poor
Availability of study material	4.3	13.0	34.8	43.5	4.3	-
Availability of equipment	4.3	4.3	30.4	52.2	8.7	-
Availability of classrooms	47.8	30.4	30.4	4.3	4.3	-
Availability of teachers/instructors	17.4	26.1	43.5	8.7	4.3	-
Availability of technical books	8.7	34.8	26.1	21.7	8.7	-
Effective use of equipment	4.3	47.8	30.4	17.4	-	-
Effective use of teachers/trainers	21.7	43.5	30.4	4.3	-	-
Effective use of study materials	13.0	52.2	26.1	8.7	-	-
Adequacy of funding	-	17.4	26.1	26.1	30.4	-

Assessment of Policy-Makers

The policy makers interviewed included vice-chancellors, deans of engineering faculties, Executive Secretary of the Council for Registration of Engineers (COREN), the body that makes regular accreditation visits to engineering training institutions and the President, Nigerian Society of Engineers. Their rating of training capacity is shown in *Table 5.15.* While all of those interviewed agreed that the existing engineering training institutions were adequate to meet the needs of employers in the foreseeable future, all of them rated the available facilities in the engineering faculties from fair to poor and very poor. All of them also rated funding from poor to very poor. Some of the vice-chancellors interviewed questioned the expediency of having as many as 26 faculties of engineering in the country. All of them produce mechanical engineers for example and from all indications, the economy can absorb only a small percentage and many remain jobless for years after graduation. They suggested fewer but larger, well-funded faculties of engineering in order to maximize utilization of resources. Asked to suggest possible ways of improving funding they listed the following:

1. Introduction of tuition fees
2. Disbursement of the education tax fund which had accumulated over a number of years.
3. Improved government funding discriminated in favour of technical education.
4. Greater involvement of engineering faculties in consultancy.
5. Special grants from the Petroleum Training Fund.
6. Reduction in the number of engineering faculties and designation of centres of excellence for specific areas of specialization in engineering.
7. Grant of loans by the Education Bank to students to facilitate payment of fees.

All the vice-chancellors and deans interviewed had difficulty in recruiting staff for the engineering faculties. They were apprehensive that the situation would get worse in view of the poor local facilities for postgraduate training and the shrinking opportunities for training in foreign countries. Another area of worry was the lack of industrial experience by teachers in engineering faculties. Most of the policy makers suggested the need for continuing education of teachers as well as government funded industrial exposure schemes.
It became clear in the course of interviewing deans and teaching and technical staff of faculties of

Table 5.15: Assessment of Training Capacity in Engineering Institutions by Policy-Makers

	Rating %					
Area	Excellent	V. Good	Good	Fair	Poor	V. Poor
Number of existing engineering training institutions	30	10	10	-	-	-
Laboratory/Workshop equipment	-	-	-	60	30	10
Library facilities	-	-	-	30	60	10
Teaching & staff/ instructors	-	-	-	40	60	-
Funding	-	-	-	-	70	-

Engineering that, even though available equipment was grossly inadequate, most of what was available was being grossly under-utilized. Most of it is operated for only a few hours in one session because each class usually comprises only a few groups. The same equipment could be utilized by much larger classes comprising many groups working in shifts.

Curriculum Structure and Content

Engineering faculties in Nigeria offer between five and seven engineering courses out of the following mechanical engineering, civil engineering, electrical engineering, electronic engineering, electronic and electrical engineering, chemical engineering, metallurgical and materials engineering, petroleum engineering, agricultural engineering, computer engineering and mining engineering. Until recently, each university had complete freedom to determine the curriculum structure and course content. The only moderating factor was the accreditation visits by the Council for Registration of Engineers (COREN), usually once every ten years to assess the quality of engineering education with a view to registering the products. However, the Nigerian Universities Commission (NUC) recently set up groups of experts in each discipline to set minimum standards. Visitation panels have also been set up to assess the extent to which these standards are met by each institution. The minimum standards in engineering have four major features:

i) All students irrespective of area of specialization take virtually the same basic engineering courses in the first two years. These courses cover basic engineering principles and concepts.
ii) Every student must spend the second semester of the fourth year in industry, in addition to the usual long vacation periods.
iii) All engineering courses must cover a period of four years after advanced level or equivalent.
iv) The examinations must be moderated by external examiners.
v) All engineering curricula must include complementary courses in economics, management and general studies.

All the engineering curricula reviewed in this study had met the minimum standards set by the National Universities Commission in respect of courses offered and course content. Most of them included management courses (91.8 percent) but very few offered courses in entrepreneurship or technology policy (10 percent and 20 percent respectively).

Assessment by Students

It was considered important to identify the factors which motivate students to choose engineering courses since this may to some extent determine their performance on the courses as well as in subsequent employment. It was considered, for example, that an enlightened background could influence the choice of course and ultimate career. However, this thesis was not supported by the findings. Whereas 74.2 percent of the students interviewed had fathers who had at least some education, only 28.8 percent got to know the course chosen through their parents or relations and only 12.1 percent were advised by their parents. Others became aware through such other sources as guidance counsellors (26 percent), friends (14.9 percent), and institutions' handbooks (16.3 percent). The majority (73.1 percent) were motivated by the desire to acquire skills and the professional nature of engineering. Most of them (62.3 percent) were on courses which they always wanted to do. Most of those who were not have always wanted to become engineers, but of different specialization. They had to accept the courses for which they were offered admission. However, most of the students in the latter category (91.6 percent) eventually grew to like the courses they were doing. The others changed courses because they found their first choice too difficult. Most of them (79.1 percent) gained admission on the basis of their performance in the Ordinary Level examination as well as the Joint Admission and Matriculation (JAMB) examination. Only 13.5 percent had worked before gaining admission and only about half of those had previous work experience were on jobs of a technical nature.

The response of students to questions on curriculum are presented in *Table 5.16.* Most of the students rated performance of teachers, variety and range of courses, relevance of courses, and theoretical content from excellent to good (83.2 percent, 62.3 percent, 91.6 percent and 96.7 percent respectively). However, 66 percent rated the practical content of courses from fair to poor/very poor. The ratings for field work and practical projects were similar (67 percent and 54 percent respectively).

The majority of the students (83.7 percent) considered their training generally very satisfactory and relevant to their chosen area of specialization. Suggestions for improvement included restructuring of the curriculum to ensure that students have enough grounding in their areas of specialization before proceeding on the Students Industrial Work Experience Schemes (SIWES), and introduction of more practical classes.

Table 5.16: Assessment by Students of Engineering Curriculum and Course Content

	% Rating					
Area	Excellent	V. Good	Good	Fair	Poor	V. Poor
Performance of teachers	11.6	32.1	39.5	12.1	1.9	2.8
Variety and range of courses being taught	18.6	43.7	30.2	6.5	0.9	-
Relevance of courses being taught	18.6	49.3	23.7	6.0	1.4	0.9
Theoretical content of courses	33.0	46.0	17.7	1.9	0.9	0.5
Practical content of courses	3.7	7.0	23.3	36.7	29.3	-
Training techniques	2.3	13.5	40.0	32.1	11.2	0.9
Field work	3.3	6.5	23.3	29.3	35.8	1.9
Practical projects	3.31	6.72	6.0	33.5	20.5	-

Assessment of Curricula by Teachers and Trainers

Most of the teachers (72.1 percent) were of the opinion that the existing curricula on engineering and technical education were of high standard and relevant to national needs. Those who responded negatively thought the courses were too theoretical, with little focus on the end user (industries). They also felt that the curricula were long overdue for review to reflect current global trends in technology. Only 57.4 percent of the teachers agreed that the existing curricula adequately prepared students for future employment. Deficiencies cited included lack of text books which reflected local applications and examples, and inadequate exposure to practicals and industrial training.

While most of the students (98.4 percent) participated in the SIWES programme, only 63.9 percent of the teachers participated in supervision. Most of them felt that the laudable objectives of SIWES were being thwarted by lack of co-operation by industries and poor supervision by teachers and industry-based supervisors. Suggestions for improvement included the establishment of industrial centres in engineering faculties and greater faculty-industry cooperation.

The responses of teachers and trainers to questions on ability of students to use effectively available training capacity are shown in*Table 5.17.* Students' attitude to their studies were rated mainly from fair to excellent (86.9 percent). Attitude to laboratory and workshop work, use of library, initiative and ability to use tools and equipment were similarly rated (80.4 percent, 80.4 percent, 77 percent, 91.8percent and 83.7 percent respectively). However, the ability of the students to relate theory and practice was rated relatively low, 13.9 percent.

Table 5.17: Opinion of Teachers and Trainers about Students' Use of Available Facilities

	Rating %					
Facility	Excellent	V. Good	Good	Fair	Poor	V. Poor
Attitude to their studies	1.6	11.5	42.6	31.1	8.2	4.9
Ability to relate theory and practice	3.3	6.6	26.2	44.3	16.4	3.2
Attitude to laboratory/workshop work.	1.6	13.1	32.8	32.8	16.4	3.2
Use of the library to enrich lectures.	3.3	14.8	27.9	31.1	16.4	6.6
Initiative	3.3	11.5	42.6	34.4	3.3	4.9
Ability to use tools and equipment.	3.3	9.8	34.4	36.1	9.8	6.5

Assessment by Graduates

About 60 percent of the engineering graduates interviewed were satisfied with the training they received. About 87 percent felt that their technical training prepared them very well for their subsequent jobs and the others felt fairly well prepared. Their rating of the curriculum and other related factors is presented in*Table 5.18.* Most of them (95.7 percent) rated the variety and range of courses offered from good to excellent. Nearly all of them also considered the relevance of courses offered and theoretical content of courses at least good (99.8 percent and 99.9 percent respectively). About 80 percent rated the practical content of courses from good to excellent compared with 82.6 percent and 86.9 percent who gave similar rating to training techniques and practical projects respectively.

However, fewer respondents (60.8 percent) rated field work from good to excellent. All the graduates interviewed rated performance of their teachers from good to excellent and 60.9 percent expressed satisfaction with the way they were trained. Those who were not satisfied complained about the practical training, poor laboratory facilities, having to do courses which they did not consider relevant, and shortage of lecturers. About 83 percent of the respondents considered the training received adequate preparation for the jobs they were doing.

Assessment by Employers and Supervisors

Nearly all the employers were not familiar with the engineering curricula and hence could not comment on the adequacy. However, most (92 percent) felt that the technical knowledge of graduates was adequate as a basis for further training for their specific jobs. They suggested improvement in writing skills, exposure to practical work, and in management training.

Table 5.18: Assessment of Curriculum by Graduates

	Rating %				
Curriculum Content/Delivery	Excellent	V. Good	Good	Fair	Poor
Performance of teachers	30.4	43.5	26.1	-	-
Variety/range of courses offered	17.4	52.2	26.1	4.3	-
Relevance of courses offered	34.8	47.8	17.2	-	-
Theoretical Content	39.1	56.5	4.3	-	-
Practical Content	4.3	8.7	60.9	17.4	8.7
Training techniques	8.7	34.8	39.1	13.0	4.3
Field work	13.0	17.4	30.4	30.4	8.7
Practical Projects	17.4	30.4	39.1	13.0	-

Employers in the consultancy sector were particularly unhappy with the poor writing skills of fresh engineers. Many have difficulty in expressing themselves and cannot develop a decent report.

Assessment by Policy-Makers

About half of the policy makers interviewed had no opinion on the engineering curriculum. Those directly involved in training and regulation of the profession were generally satisfied with the curriculum. Most, however, were of the opinion that practical courses and industrial training should be strengthened and entrepreneurship courses should be introduced to prepare the products for the opinion of self employment.

Post-qualification Training and Performance

Graduates of Nigerian engineering faculties working in both the public and private sectors were interviewed to find out their opinion on the usefulness of their training with respect to their jobs. They were requested to assess the adequacy and relevance or otherwise to the curricula and make suggestions for improvement . Their employers and supervisors were also interviewed on the performance of the graduates, on observed deficiencies, and on suggestions for improvement of the training programmes in order to better prepare them for future employment.

Assessment by Graduates

Most of the graduates (82.6 percent) considered their prior training adequate for their subsequent jobs. Only 56.5 percent received any further training from their employers before starting the job. Of those who received further training, 64.3 percent received on-the-job training, 14.3 percent were trained in a similar local establishment while 21.4 percent were trained in similar foreign establishments. The duration of training ranged from three months to two years. About half of the respondents had received further training since they started their jobs, the duration ranging from a few days to two years. This included workshops, seminars, on-the-job training and training in foreign establishments. About 69.2 percent received technical training while the others received management training.

The graduates were asked to rate the extent to which their technical training adequately prepared them for their subsequent job responsibilities Their responses are shown in*Table 5.19.* It is clear from the table that most graduates were satisfied with their technical training for their subsequent jobs.

The graduates were also asked whether or not their technical training enhanced various aspects of their professional career and their responses are shown in*Table 5.20.* Over 60 percent agreed that the technical training they received enhanced their professional advancement but 43.5 percent believed that it enhanced their monetary earnings. Suggestions on how technical education could be made more relevant to future employment include:

- interaction between institutions and industry on curriculum development.
- regular review of curriculum to take account of new development in technology.
- greater emphasis on practical training.
- introduction of courses on business management.

Assessment by Employers of Post-qualification Training and Performance

The companies were selected from both public and private sectors and had employees between 200 and 6,000. Most of the companies recruited their employees mainly through advertisements but some of the big ones visit tertiary institutions annually. Nearly all of them (83 percent) had training programmes for fresh recruits. Only 40 percent had in-house training schools while others train by short-term attachment to experienced supervisors in relevant sections. About 45 percent use other training facilities within and outside the country. The scope and duration depend on the

Table 5.19: Rating by Graduates of Adequacy of Technical Training for Subsequent Employment

	Rating %				
Aspects of Employment	V. Well	Well	F. Well	Poorly	V. Poorly
Application of knowledge	26.1	60.9	13.0	-	-
Work responsibility	30.4	65.2	4.3	-	-
Career development	34.8	43.5	21.7	-	-
Job challenges	43.5	30.4	26.1	-	-
Job security	26.1	43.5	21.7	4.3	4.3
Use of initiative	30.4	47.8	21.7	-	-
Creativity	39.1	30.4	30.4	-	-
Use of tools/equipment	26.1	47.8	17.8	8.7	-

Table 5.20: Graduates who Felt that their Technical Training Enhanced Various Aspects of their Professional career

Enhancement of Career Profile	Yes %
Job opportunities	91.3
Monetary gains	43.5
Professional advancement	87.0
Promotion prospects	60.9
Performance at work	95.7
Job satisfaction	73.9
Marketability	69.6

nature of the job. The duration of initial training is one to twelve months but some of the employers (45 percent) have continuous and comprehensive training programmes and the average engineer is likely to go on a training programme at least once in two years.

The primary objective of the initial training is to adapt the recruit engineer to his job schedule as well as to the work environment. Subsequent training is usually focused on improving technical competence or acquiring managerial competence. It is also often necessary to re-train their employees when there is a change in the scope and complexity of responsibilities.

As much as possible, respondents were senior technical personnel, with responsibility for supervising young engineers. About 60 percent of them had varied prior working experience with other companies and nearly all of them (85 percent) supervised at least five engineers. Their responses to the various questions on the performance of their subordinates are presented in *Table 5.21.* Employers were mostly satisfied with the performance of graduate engineers on the job, with all of the respondents rating them from good to very good. However, the rating in non-technical knowledge, practical knowledge and innovation were not as good, with 50 percent, 58.4 percent and 50.0 percent rating them as only fair. The majority of the respondents rated them from very good to good in technical knowledge (83.4 percent), initiative (75.0 percent), respect for authority (83.3 percent), willingness to accept authority (91.7 percent), ability to adjust to working environment (79.1 percent), and working relationship with others (66.7 percent).

The responses of the employers to a request to rate the job performance of the various categories of technical graduates in their employment are shown in *Table 5.22.*

Table 5.21: Assessment of Performance of Technical Graduates by Employers' Supervisors

Area	Excellent	V. Good	Good	Fair	Poor
Technical knowledge	-	41.7	41.7	17.6	-
Non-technical knowledge	-	25.0	25.0	50.0	-
Performance on the job	-	62.5	37.5	-	-
Practical knowledge	-	20.8	20.8	58.4	-
Initiative	-	33.3	41.7	25.0	-
Respect for authority	-	20.8	62.5	16.7	-
Willingness to accept authority	-	54.2	37.5	8.3	-
Ability to adjust to working environment	-	20.8	58.3	12.5	9.0
Innovation	-	8.3	41.7	50.0	-
Working relationship with others	-	4.26	2.5	29.2	4.1

The majority of employers rated all categories of technical graduates from good to fair, 66.7 percent for vocational college graduates, 66.7 percent for graduates of technical colleges, and 58.3 percent for university graduates.

Female Engineering and Technical Education

There is gender disparity in education in favour of men at all levels of education in Nigeria. School enrolment is significantly lower and drop out rates higher among girls. A recent estimate (World Population Data Sheet, 1992) indicated a literacy gender gap of 22 percent in favour of men. The situation is worse in higher education. Available statistics indicate that women constitute less than 25 percent of the total university enrolment and the proportion estimated at about 10 percent is considerably lower in science and technology programmes.

Nigeria, in response to several global and regional initiatives, produced a blueprint on women's education in 1986, the policy thrust being to improve women's access to education through formal and non-formal systems. Women education centres were established in collaboration with UNICEF. However, many of the centres have not been able to meet their noble objectives due to lack of finance (Osemwegie et al, 1993).

There is no specific policy on enhancing female representation in tertiary education through preferential admission or scholarship scheme, although informal action is often taken to encourage girls. For example, in 1987, the Federal Scholarship Board selected for postgraduate scholarship award every female who met the minimum qualification. Yet, women won only 8.6 percent of the awards for that year. Data obtained from this study from a survey of over 30 engineering programmes in six Nigerian universities also show that females constitute only about 10 percent on the average of the total enrolment but varies widely depending on the course as evident in *Tables 5.23* and *5.24* which shows the proportion of females graduating from faculty of engineering and departments respectively, in one of Nigeria's Federal Universities in 1997. It is clear from the tables that the proportion of females on some engineering courses is as low as two percent and those who opt for technical courses tend to avoid the traditional disciplines civil, mechanical and electrical engineering, computer science, computer engineering and food science and technology.

Opinion of Students on Females Engineering and Technical Education

Table 5.22: Assessment of Categories of Technical Graduates by Employers

	Rating %				
Category	Excellent	V. Good	Good	Fair	Poor
Graduates of vocational colleges	-	20.8	16.7	50.0	12.5
Graduates of technical colleges	-	33.3	41.7	25.0	-
Graduate engineers from universities	-	41.7	41.7	16.6	-

Table 5.23: Female Component of Graduating Students of one of Nigeria's Federal Universities in 1997

Faculty	Total Graduands	No of Females	% Females
Administration	251	63	25.1
Arts	315	89	28.3
Education	447	203	45.4
Law	184	53	28.8
Social Sciences	241	56	23.2
Agriculture	227	32	14.1
Health Sciences	300	45	15.0
Environmental Design & Management	191	25	13.1
Pharmacy	103	32	31.1
Science	385	61	21.4
Technology	477	51	10.7
		Average	10.7%

Table 5.24: Proportion of Females in a Graduating Class of Faculty of Engineering of one of Nigeria's Universities in 1997

Programme	Total Students	No of Females	% Females
Agricultural Engineering	53	3	5.7
Chemical Engineering	90	8	10.0
Computer Science	82	11	13.4
Computer Engineering (math or econs option)	38	3	7.9
Civil Engineering	30	2	6.7
Electronic & Electrical Eng.	62	2	3.2
Food Science & Technology	35	19	54.3
Mechanical Engineering	50	1	2.0
Metallurgical & Materials Eng.	38		2.6
		Average	10.7%

Students generally favoured encouragement of females in engineering education or profession. When asked whether or not females should be encouraged, 83.3 percent answered in the affirmative. Reasons adduced by those who did not support encouragement included engineering being too strenuous for females, being too masculine and being a masculine preserve. Most of the respondents who felt that females should be encouraged would want females to take up only technical careers that do not involve physical strain such as electronics, computer science and engineering, architecture, food science and technology. A higher percentage of the respondents (56.3 percent) felt that females should be given special incentives to take up technical careers. However, only 11.67 percent of those who supported incentives wanted lower admission cut off point for females, compared with 48.1 percent who supported a special scholarship schemes and 28.7 percent who would want a special admission quota for females. Only 45.6 percent of the students interviewed felt that females were less able to cope with technical courses compared with males. Reasons given by this group for their position included women having a weaker biological and physical make-up compared to men, women's inability to cope with the strenuous nature of technical courses, society pressures and the complex nature of females.

Opinion of Teachers and Trainers on Female Technical and Engineering Education

Over 93 percent of the teachers and trainers interviewed were of the opinion that females should be encouraged to take up technical careers. Those who did not agree felt that the profession was too difficult and too dirty. A majority of the respondents (73.8 percent) saw no need for any restriction on the type of technical career that females should take up. Those who were of the opinion that a restriction was necessary felt that the profession was to strenuous and women should only be encouraged to take up such 'softer' courses as electronics and computer engineering. About 67 percent of the respondents supported some form of incentives for women to take up technical careers. Suggestions include special scholarships (52.3 percent) and special admission quota (29.6 percent). However, only 4.5 percent supported a lower admission cut off point. Nearly 74 percent of the respondents did not feel that females were less able to cope with technical courses compared with men. Problems highlighted by those who felt they were inferior included socio-cultural factors which had affected their performance at the primary and secondary school level, dislike by females for quantitative subjects, and inability to cope with the strenuous nature of technical courses.

Opinion of Graduates on Female Technical and Engineering Education

Graduates also supported the position that females should be encouraged to take up technical careers, with 91.3 percent answering in the affirmative. The few who did not support thought it was too difficult. About 48 percent of the respondents thought that not all technical courses were suitable for females. They suggested that females should choose only the less strenuous courses. About 56 percent supported special incentives, with 46.2 percent wanting admission quota for females and 30.8 percent supporting special scholarships for females to enable them pursue technical courses. Only 15.4 percent felt that there should be a lower admission cut-off point for females. About 65 percent of the respondents did not agree that females were less able to cope with technical courses compared with males. Those who felt otherwise thought that only some of the females were capable and that females were a weaker sex.

Opinion of Employers on Female and Technical Education

Nearly all the employers interviewed (90 percent) agreed that females should be encouraged to opt for technical courses. Most, (90 percent) did not support any restriction on the types of technical courses suitable for females. They saw no reason for this, considering that fact that they had observed no difference in performance in employment. Nearly all the respondents (90 percent) supported special admission quota and scholarship schemes as incentives for encouraging females to take up technical careers. None of them supported the suggestion of a lower admission cut-off point for females.

Opinion of Policy-Makers on Female Engineering and Technical Education

All the policy-makers interviewed acknowledged gross under-representation of females in technical education and supported that they should be encouraged. None of them felt that there should be any restriction on the type of technical courses suitable for women. While all of them supported such incentives as special admission quota and scholarship schemes, none of them agreed that there should be a lower admission cut-off point for females. They felt that such a policy would put them at a psychological disadvantage among their male colleagues. None of the respondents thought that females were less able to cope with technical courses than males.

Chapter Six

Country Report - Ghana

Introduction

Ghana is located on the West Coast of Africa, about 750 km north of the equator, between latitude four and 11.5 degrees north and longitude three degrees west and one degree east. The country occupies 238,537 sq. km of territory and has a population of about 17 million. Ghana is endowed with extensive vegetation, wildlife and mineral resources and is well known for the production of gold. Essentially, Ghana maintains a dualistic economy based on relatively modern capital intensive sector and a large traditional sector mainly engaged in agriculture and informal activities. Previous governments as well as the present one believe that a systematic application of science and technology to meet socio-economic objectives is the only way to reduce the country's poverty and other economic problems. Science and technology is perceived as being capable of promoting industrial development and encouraging the development of indigenous capabilities and capacity. Policy makers are reluctant to accept that there is no proper policy document governing, specifically, engineering (technical) education which has, since time immemorial, been guided by science and technology and strategic planning documents.

Prior to independence (1957), Ghana had a few technical institutions that were concerned mainly with the training of middle manpower for the mining industries that existed at the time. The post-independence industrialization policy resulted in the establishment of many technical institutions. The aim was to introduce and promote educational programmes focused on technical training and to seek to muster scientific and technological capabilities with the view to developing an infrastructure that would enable industries to provide the need of the society.

Although Ghana has been known for providing quality education, over the past few years, concern has been raised over aspects of the country's educational system. The government has the view that the educational budget is unduly high. Besides, the system has not been responsive enough to national needs. There also have been concerns on the falling standards of education. The culmination of these concerns has indicated a need to restructure the educational system to minimise cost, make it more relevant to national development.

The desire for rapid industrialization has placed engineering and technical education in the searchlight since it is the belief that science and technology is the means to the country's development. Many issues need to be addressed in order to make engineering education more relevant. This study was therefore conceived in this light and it involved the use of a questionnaire to obtain as much detailed information as possible. Students, teachers, graduates, policy-makers and employers were interviewed on a wide range of issues relevant to engineering education.

Government Policy Relating to Education and Technical Education

The government's principal on science and technology is to actively encourage, promote and support the development of indigenous science and technology capabilities for the development of indigenous technologies and for the selection, acquisition, adaption, absorption and regulation of technologies appropriate to the nation's development. The priority areas include agriculture, forestry and fisheries, health and medicine, industry and natural science, environment and social science. The aim is to infuse the culture of science and technology into all levels of the society to enable the country to attain middle income status as envisaged in the Vision 2020 document.

Therefore, since 1987, the government has embarked on significant reforms in the educational system. The reform policies include:

- Provision of all school going children with basic primary and secondary education.
- Introduction of more vocational elements in education and thus offering opportunity for more practical skill acquisition; this is to shift emphasis from the overall academic orientation to a more problem solving technical one.

The first policy provides for what is termed as the Free Compulsory Universal Basic Education (FCUBE) which covers six years of primary and three years of junior secondary education from age six. This is followed by three years of senior secondary education before tertiary education. Thus the old system of 17 years of pre-tertiary education, made up of 10 years of primary and middle (basic), five year ordinary level and two year advanced level, has been replaced by 12 years of pre-tertiary education. This leads to a reduction of five years in pre-tertiary education. The new structure initiated in 1987 was firmly in place by 1993.

Thus in the current system, basic education comprises primary and junior secondary education. Senior secondary education encompasses the grammar secondary, vocational and technical schools. Owing to the few openings in the purely vocational and technical schools, the course contents in many of the senior secondary schools have been broadened to cater for the science, technical, vocational as well as social and business studies.

Before the reforms began, many secondary school leavers usually aimed at continuing tertiary education in the universities. There were three universities at the time with limited openings and course offering. Other tertiary level institutions were scattered under various ministries. To rationalize access to tertiary education, improve co-ordination in management and to reduce costs, the tertiary reforms were introduced. The government's white paper on the tertiary reforms gives details of the objectives of the reforms. The white paper acknowledges that during the over two decades of tertiary education, despite the reputation that Ghana has for providing good quality graduates, review of the impact of the universities on society and the national development process has shown a growing divergence between university education and the national development process. This has therefore urged a reappraisal of course content and orientation as well as a revision of the models of institutional organization in order to avoid this divergence. Again, the white paper mentions the adverse effect of the national economic crises in the 1980s on education in general and tertiary education in particular. This has led to falling standards, lack of equipment and essential teaching materials, low morale among staff and stagnation. It was also observed that was a lack of flexibility in course structure and admission policies causing overlaps between programmes, and further reducing access.

The objectives to be achieved in the tertiary component of the education reform programme included revamping, recapitalization and expansion. These were to be accompanied by the programme of cost reduction and waste elimination. To ensure sustainability, a system of cost sharing between government, community, parents, students and educational institutions was to be set up.

There are indications that the laudable objectives of the recent reforms of educational policy in Ghana are not being realised and new problems may in fact be emerging as a result of the reforms. Primary school registration has increased significantly, but so has the drop out rate which is estimated at over 60 percent. About 75 percent of those who complete primary school do not go to secondary school, thus creating a huge pool of unemployed graduates for whom there is no apprenticeship training programme. Acute shortage of trained teachers has made the practical training workshop concept a mirage. Only about 24 percent of schools surveyed recently had functioning, if adequate, workshops (Amanake, 1993). The teaching of science in schools has not improved as a result of shortage of qualified staff and laboratory facilities, hence the impact on engineering education has been minimal. In a recent study (ADAE, 1995), these problems were attributed to the fact that government embarked on extensive and far-reaching reforms without policy analysis in related studies.

Assessment of Policy on Engineering and Technical Education

Assessment by Students

About 60 percent of students interviewed in this study think that the country's policy on technical and engineering education falls within good to excellent category. 40 percent, however, find the policy to be poor to fair. Only 22 percent find the pace of technological development to be good, 78 percent find this to be poor. Among the reasons given for the slow pace of technological development in the country are:

- lack of funding
- lack of motivation for research
- lack of strong government policy since policy-makers generally lack the technical know-how or do not appreciate technology

- low standard and poor course content of technical education.

Students, however, suggest the following for improving the policy and accelerating the pace of technological development:
- increase the practical content of technical education
- provide more modern facilities for practicals as well as for teaching (e.g. equipment, computers, visual aids etc.)
- introduce technical courses in primary and secondary schools
- enhance entrepreneurial skills for self employment

Assessment of Policy by Trainers

Only about 50 percent of trainers appeared to be aware of any specific government policy on technical and engineering education. For these people, the policy has influenced their teaching and curriculum in such a way that they have introduced relevant courses in the curriculum. Others had not seen any positive influence of government policy on the curriculum.

Over 75 percent have never participated in the formulation of government policy on technical education and as such have had no input into the policy. The few have participated in formulating some of the policies, especially the science and technology policy, said their input was on materials technology. Over 50 percent of respondents made suggestions for improving government policy on technical education. The suggestions include having:
- more tutors to be trained for technical education
- more incentives to be given to the tutors
- discussion of policy from the initial stages
- policy-makers point of view must not necessarily be the one to be accepted, e.g. the views of the Ministry of Education.
- more facilities and equipment provided.

Assessment by Graduates

The opinion of graduates on policy of technical and engineering education is that of fair to good (55 percent). Those interviewed similarly assessed the pace of technological development in Ghana to be fair to good (67 percent). These views of the graduates are only slightly on the negative spectrum from those of the students.

The graduates gave similar reasons for the slow pace of technological development, i.e. lack of funding and the absence of a coherent government policy. The suggestions made for improvement include:
- provision of adequate equipment and resources (i.e. lecturers)
- improvement of the practical (industrial)content of technical and engineering education
- employment of workable government policy on technological development

To make technical education more relevant to national development, they further suggested counselling services and the involvement of industry in developing curricula and in training.

Assessment by Employers andSupervisors

Half of employers interviewed said that as end users they participate in the planning of technical education in the country. The major contribution, they stated, is in giving inputs into curriculum development and giving students (undergraduates) practical and industrial training. Those who said they did not take part in planning of technical education would like to participate.

Employers mentioned the following as being the problems of technical education in Ghana lack of practical training, lack of infrastructure, lack of teachers, lack of field exposure and lack of government commitment. They suggested the following to help government and institutions improve technical education:

- technical education must be made practical
- lecturers must have industrial experience to enhance their knowledge
- schools should offer more relevant courses
- training materials and facilities must be provided
- career guidance should be given prominence
- assistant must be sought from industry

Assessment of Policy by Policy Makers

The majority of policy-makers interviewed were from government ministries and parastatals (universities) and were in the senior management positions. The policy on technical education is said to have been in place for at least 10 years. The majority agreed that the main thrust of government policy on technical education is to train technical manpower for all levels of employment (especially middle level manpower) and to develop a base for advancement in technology.

About 60 percent considered the policy adequate for the stimulation of rapid technological development of the country. Those who did not agree with this said there were certain deficiencies in the policy. Some of the deficiencies were identified as training not being geared to specific manpower requirements and hence making certain technical areas saturated. Also, poor policy implementation, inadequate personnel and infrastructure were identified as deficiencies in the policy implementation. About 40 percent of the establishments in the interview had been involved in formulation and review of government policy on technical education. This is done through the review of draft policies, conferences, use of questionnaires to solicit views on policy formulation, and in research. Majority of those who were not involved felt that their establishment should have been involved. Respondents were asked to rate the achievements of the objectives of the National Policy on Technical Education. The reasons are summarized in*Table 6.1.* As may be seen from the table the majority of the respondents rate the various achievements as fair, or at best good. The achievement in establishing multi-purpose vocational and technical schools in every district is rated as poor.

Respondents were asked whether their establishments had reliable statistics on certain areas of technical training and manpower. The responses are summarized in*Table 6.2.* The table shows that many of the establishments did not have reliable statistics on which the formulation of future training schools or manpower training could be based. In the absence of any reliable statistics, the establishments indicated the following as guiding principles in their contribution to the formulation of policy on technical education:

- the interest of student applicants to technical education
- non-availability or inadequacy of technical facilities
- the need to provide higher technical education and research
- private knowledge and information

Generally, respondents gave the following suggestions on how the national policy on technical education can be made more responsive to the needs of the country:

- manpower requirement must be known
- government must state its development policies
- more technical schools should be opened
- science and technology must be introduced into basic education
- more emphasis should be placed on science education in the secondary schools
- technical training must be practical oriented
- polytechnics and other technical institutions must be given special attention
- laboratories and workshops must be well-equipped.

Resource Capacity for Engineering Education in Ghana

The areas designated under tertiary education may be grouped as follows:

a) universities
b) polytechnics and other diploma awarding institutions
c) teacher training colleges.

Of relevance to this study are polytechnics and universities. Since the white paper was issued, much has changed in Ghana's tertiary education system. Two new polytechnics have been created and two new universities have been established. Currently there are eight polytechnics. These are located at Accra, Ho, Kumasi, Tokaradi, Sunyani, Tema, Cape Coast and Koforidua. The Polytechnics offer courses up to the diploma level. Diploma courses in the universities are therefore being phased out. There are plans to introduce B.Tech degree in the polytechnics.

There are currently five universities in Ghana: the University of Ghana at Accra, the University of Science and Technology at Kumasi, the University of Cape Coast at Cape Coast, the University of Development Studies at Tamale and the University College of Education at Winneba. The universities offer degree programmes up to the Ph. D. level. The University of Science and Technology (UST) caters for almost all the engineering programmes.

Table 6.1: Objectives of the National Policy on Technical Education

Objectives	% Rating					
	Excellent	V. good	Good	Fair	Poor	V. poor
Training of Technical teachers	-	-	-	60	40	-
Fairly introduction of elementary technology in the school system	-	-	60	20	20	-
Introduction of skill forming technical courses into the secondary schools	-	20	40	40	-	-
Restructuring of technical curricula to broaden the scope and focus on national needs	-	-	20	80	-	-
Establishing multi-purpose vocational and technical schools in every district	-	-	-	-	40	60
Integrating the teaching of science and technology to promote appreciation	-	-	60	40	-	-
Provision of well equipped workshops for junior secondary schools and technical colleges	-	-	-	60	20	20

Table 6.2: Responses on Availability of Statistics on Area of Technical Training

Area	%Yes	% No
Current population and mix of technical manpower in the country	20	80
Projections of the country's technical manpower	40	60
Existing technical training establishments	60	40
Projection of future requirements of technical training establishments	20	80

In a document of the nation's development strategies, Vision 2020, the government has stated its intention to facilitate the establishment of centres for engineering and manufacturing, and pilot and demonstration plants in selected institutions to promote indigenous technologies. It is also intended to accelerate the mastery of known technologies as prime importance in the industrialization programme.

During the reforms the government sought assistance from the World Bank to support the Tertiary Education Project (TEP). Buttressed by this assistance, the government embarked on some strategies to improve on the capabilities and capacities in the polytechnic and reinforce the departments of the University of Science and Technology to meet the needs of the nation. Within the period, there has been a dramatic increase in enrolment in the tertiary level by about 80 percent.

Financing of Engineering Programmes

The government in recent times has become more concerned with the increasing proportion of total recurrent budget allocated to education. This is because education thrives mainly on government subvention. Tuition is free for all Ghanaians. However, students have to provide their own meals and pay some minimal amount towards facilities. Many students (about 90 percent) depend on government loans, the cedi equivalent of about $320/yr. About 10 percent of the students are supported by their parents.

A breakdown of occupation of fathers (from this study) is shown in*Table 6.3.* This indicates that only about 40 percent of parents are likely to be able to make meaningful contribution in terms of cost sharing. Scholarships and grants from government employers etc. would be essential to cater for the remaining 60 percent and this factor must be borne in mind on any discussion on cost sharing. In 1996, 40 percent of the total national budget was allocated to the education sector alone. In 1997, 36 percent was allocated. *Tables 6.4a* and *6.4b* show the budget allocation to Education and the proportion of it allocated to tertiary education which includes the polytechnics, the diploma-awarding institutions as well as the universities. As part of the reforms, the universities are changing their budgeting system from the line budget to the programme-linked budget. The programme-linked makes use of the student Full Time Equivalent (F.T.E) ration for each faculty. The assumption is that the more students a faculty handles, the more funds it must receive. The unit cost for training an engineering student has been determined to be about c5 000 000.00 ($2,500 in 1990) a year. However, the funds usually released have never matched the number of students.

A monitoring exercise by the World Bank in connection with its assistance to the Tertiary Education Project (TEP) indicate that in 1990, the government spent about $2,500 for each university student and $180 per polytechnic student. In 1992 the figures were $2,000 and $130. Based on international standards these were acceptable indicators for quality education. However, these amounts were reduced by 40 percent in 1997 and by over 50 percent in 1998, thus making the current expenditure $900 and $74. This decline is likely to affect the quality of education.

In real terms, the apparent increase in the allocation to education is seriously affected by inflation (about 30 percent in 1997-1998) coupled with a 22 percent increase in enrolment in the same period. Recurrent expenditure (Items 2-5) required for laboratory equipment, consumables, computer maintenance, books, journals and research has been drastically reduced. This makes teaching at this level far below the expected standards. The 1998 budget is so constrained that it can fund little more than staff salaries. Only about 45 percent of the U.S.T. proposed budget is being provided in 1998. The overall allocation to the education budget (1998) is about the same level as in 1997. The 1998 figures are provisional.

The total subvention for the universities is expected to be distributed according to the following norms:

	Function	**% of total available**
i.	Direct teaching costs	45
ii.	General education expenses	15
iii.	Library	10
iv.	Central administration	6
v.	Staff and student facilities	5
vi.	Municipal services	15
vii.	Miscellaneous	4

Again owing to the limited funds available it has not always been possible to stick to the norms. A number of institutions, including the engineering institutions, are self-accounting i.e. they receive their subventions directly from government. Usually this may be either slightly higher than the average or about the same as those who receive their funds through the university administration. The Government of Ghana has identified sustainable financing as a necessary condition for achieving the improved quality of education and the expanded enrolment required. Having realized that the cost of education has become too much to bear, especially in the wake of numerous government programmes coupled with insufficient financial capabilities, the government is proposing a tertiary system of education in which the cost would be shared with the beneficiaries. These are the government, the students, and the employers. The student leadership is, however, opposed to any charges being passed on to students.

The universities are expected to carry out income generating activities to supplement government subvention. The traditional sources of extra funds have been from the following:

1. Fees paid by overseas students (tuition is free for Ghanian students).
2. Registration and admission fees paid by students.
3. Rent received from staff accommodation.
4. Funds donated by private individuals or group supporting particular faculty or project, for example the ODA,The Ghana Chamber of Mines, CIDA, USAID, the GTZ, etc.

These extra sources amount to less than 10 percent of the budget and are not sufficient to supplement the huge deficit of about 55 percent left by government.

Table 6.3: Occupation of Father of the Student Respondent

Father's Profession	% of Student Respondents
Farmer	26
Teacher	10
Professional (engineer, doctor, lawyer accountant etc.)	30
Businessman	12
Retired/deceased	20

Table 6.4a: Budget Allocation to Education (c)

Year	Allocation to Education (x109c)	Allocation to Tertiary	Allocation to U.S.T (x109c)	Allocation to Eng. (c)	Allocation to Science (c)	Allocation to Non-Science (x109c)
1994	187.0	12.4	6.0	64.2	1,432.0	688.2
1995	252.7	23.5	6.1	844.1	2,167.9	1,117.7
1996	332.7	30.0	12.0	1,437.1	3,094.4	1,779.2
1997	397.7	43.4	16.1	1,639.9	3,939.6	2,107.5
1998	*400.0	*44.0	16.9	1,714.0	4,341.8	2,372.4

* Provisional figures

Table 6.4b: Budget Allocation (%)

Year	Allocation to Education (x109c)	Allocation to Tertiary	Allocation to U.S.T Sector	Allocation to Eng.	Allocation to Science	Allocation to Non-Science
1994	187.0	6.6	3.2	0.03	0.77	0.37
1995	252.7	9.3	2.4	0.33	0.86	0.44
1996	332.7	9.0	3.6	0.43	0.93	0.53
1997	397.7	10.9	4.5	0.59	1.4	0.7
1998	*400.0	11.0	4.2	0.43	1.1	0.59

Student Enrolment

The total enrolment to the University of Science and Technology degree programmes for the past five years is listed in *Table 6.5.* The respective percentage admitted for engineering, science and non-science programmes are also shown. *Table 6.6* shows the number of graduates produced in the last three years. Since 1992, the University of Science and Technology has experienced an increase of over 200 percent in enrolment. The current average is about three times the enrolment in 1992. The prescribed norm envisages an annual increase of 20 percent in favour of science and engineering. The number of graduates, however, appears to be constant, being over 1000/yr. In each case, however, engineering students or graduates average about 25 percent. The increase in facilities or funding is, however, far less than this increase in enrolment.

The total number of students (including a few diploma students) as at 1997/98 stands at about 7276. About 20 percent of this number is female. For the 1997/98 engineering enrolment, about 40 females representing seven percent were admitted. One of the goals in tertiary education is to achieve 50 percent enrolment for females.

Teaching and Support Staff

UST employs a total of 2,565 staff, 430 of whom are involved in actual teaching and research. Out of the 430, 90 are directly in teaching programs leading to various degrees in engineering. The tertiary reforms have introduced a system where the teaching and non-teaching staff are based on the number of students.

The operating norms for a department are determined thus: professors 20percent, senior lecturers 30 percent, and lecturers 50 percent.

The actual number of teaching staff is determined by the student teachers ratio (STR). For engineering and science this is 12:1, compared to 18:1 for the social sciences. Based on the number of teaching staff, the following norms have also been determined for support staff in science and engineering-based programmes: senior administrative staff 1:6 teachers, senior technical staff 1:5 teachers, junior technical staff 4:8:6 teachers, and junior non-technical staff 1:3 teachers.

These figures differ only from the non-science norms in the senior technical staff category where the ratio is 1:10. With this ratio, many departments found themselves to be overstaffed. However, the increasing enrolment is gradually bringing the staffing situation to the norms and increasing pressure on academic staff. In situations where recruitment is possible, young people are not prepared to become academics because of the low remuneration. In departments most of the staff is over 50 years.

Table 6.5: Student Enrolment at University of Science and Technology, Kumasi, Ghana

	1992/93		1993/94		1994/95		1996/97		1997/98	
Item	No	%	No	%	No	%	No	%	No	%
Engineering	189	24.5	260	20.1	269	16.6	389	17.8	544	25.1
Science	300	38.9	573	44.2	679	41.9	984	46.3	1037	47.8
Non-Science	282	36.6	463	35.7	673	41.5	752	35.4	588	27.1
Total	771	100	1296	100	1621	100	2125	100	2169	100

Table 6.6: Production of Graduates at the University of Science and Technology Kumasi, Ghana

Item	1993/94	1994/95	1996/97
Engineering	242	242	275
Science	485	576	536
Non-Science	547	458	507
Total	1274	1409	1318

Note: There was no enrolment or graduation in 1995/96.

Facilities

Many technical institutions in Ghana have some form of laboratory and workshop. However, for the many years since they were established there has not been many major rehabilitation of the facilities. Some equipment has never been serviced and some has become white elephants. Most of equipment is archaic and needs to be replaced. Modern facilities are required for the training of engineers of international standards.

The situation is critical at the university where the highest level of manpower is developed. Owing to the limited facilities, class hours have to be organized for two or more batches of students. This causes excessive load on the instructors.

In an effort to revamp the facilities, however, a World Bank assistance to the Tertiary Education Project (TEP) has made some vital equipment available to a number of engineering and science programmes. However, this is not to the required level.

The World Bank also assisted the library with the acquisition of books and journals. From 1992-1995, additions to the book stock averaged 60-70 percent (about 3,500 books) a year. It is estimated that a three-fold increase is the requirement for a year. For the past two years, with a declining support from the World Bank, the situation has worsened. However, through the World Bank assistance, an extension to the library has been provided to offer more seating space. The former seating space for 250 persons has thus been increased by over 1000. This is considered to be adequate.

According to the norms for allocating funds to the various units of the university, the library is to receive 10 percent of the university budget. However, the university affords only 4 percent.
To support the central university library, each faculty or institute has its own library with a specialized collection. These libraries are, however, smaller in capacity.

Assessment of Resource Capacity for Engineering Education

Assessment by Students

Many students interviewed got to know about their programmes of study from friends (47 percent) and parents (23 percent). Other sources, such as counselling units, newspapers and handbooks were not very helpful. However, the majority (56 percent) are doing programmes they did not opt for.They wanted to do other programmes such as civil engineering or the medical sciences. However, once enrolled, the majority liked the programmes (over 90 percent).

On what motivated students to select specific engineering programmes, many (40 percent) based their decision on the acquisition of knowledge and skills and (32 percent) based their decision on professional advancement. Only 11 percent chose their programmes on the advice of parents. Monetary gains accounted for only 9 percent of decision to choose a particular programme.

Over 93 percent of students found their programme. The majority of these were General Certificate of Education Advanced-Level holders. Senior Secondary School Certificate (SSSC) holders, whose standard is below A-level, did not complain much about their science background. This may be because of the method of selection which was based not only on the SSSC examinations but on the University Entrance Examination (UEE) as well. Selection based on this ensured that majority of SSSC holders were able to cope with their programmes. Engineering student assessment of resource capacity is summarized in *Table 6.7*.

As may be seen from the table, over 60 percent found the availability of study materials, equipment and teachers and instructors to be good to very good. This number also felt that teachers and instructors and study materials were being effectively used. Over 70 percent found the availability of the classrooms to be fair to good. Over 40 percent of the students felt that equipment was not being effectively used and almost 50 percent found the adequacy of funding to be fair. The overall picture is that students seem to find the basic facilities to be adequate but were not happy the way the equipment was being used or with the availability of classrooms. Most of the students were unhappy with funding. The availability of technical books and journals was rated to be poor to fair (over 50 percent).

Assessment by Teachers and Trainers

All trainers and teachers interviewed were found to be specialists in various fields of engineering and had university education (about 58 percent) to the postgraduate (M.Sc.) level. About 75 percent had some industrial experience prior to their current jobs, and the majority had been in teaching for 16 between 25 years (76 percent). Interest has been the main motivation for teaching (75 percent), while job security was minor (25 percent).

The trainers listed facilities available relating to courses: laboratory, electrical equipment and infrastructure. Only a few (17 percent) said facilities were adequate, the majority (83 percent) did not find the available facilities adequate. Those who found the facilities available inadequate rated the various areas as shown in *Table 6.8*.

The majority of trainers rated teaching, laboratory, workshop and library facilities as poor to fair as did the students and graduates. Again, like the students and graduates, the trainers rated themselves good to excellent. Many trainers believed that any increase in enrolment must be based on the number of teachers and facilities available. Thus, contrary to government, trainers felt there was no room for admitting more students into science and engineering.

Table 6.7: Student Assessment of Resource Capacity

	% Rating				
Area	Excellent	V. good	Good	Fair	Poor
Availability of study material	7.0	24.6	52.6	15.8	-
Availability of equipment	5.3	24.6	47.4	22.8	-
Availability of teachers/instructors	5.3	26.3	38.6	26.3	3.5
Availability of classrooms	1.8	14.0	45.6	31.6	7.0
Effective use of equipment	1.8	7.1	35.7	44.6	10.7
Effective use of teachers/instructors	3.6	19.6	60.7	16.1	-
Effective use of study material	3.6	21.8	50.9	18.2	5.5
Adequacy of funding	5.5	16.4	29.1	49.1	-
Availability of teaching books/ journals	1.8	7.1	35.7	44.6	10.7

Assessment by Graduates

About 87 percent of graduates interviewed were satisfied with the training they had. In assessing the resource capacity, however, varied responses were obtained. These are summarized in *Table 6.9*.

As may be seen from the table, over 60 percent of the graduates, like the students, found the availability of study materials, teachers and instructors and their effective use to be good to excellent. Unlike the students, however, over 50 percent of the graduates found the availability of equipment to be poor to fair, and availability of classrooms to be good to excellent. Opinion seems to be divided on the effective use of equipment between fair, good and very good. Students rated this area to be fair to good. On adequacy of funding the graduates were more critical, rating this area to be poor to fair. The graduates' rating on technical books and journals and only slightly more positive than the rating of the students, being fair to good.

A closer look at the responses revealed that graduates employed in well-established and better organized companies complained about equipment and facilities for their education as inadequate. The other group working in government establishments had a contrary view. However, both groups suggested some kind of continuing education to update their knowledge of current trends.

Assessment by Employers and Supervisors

Employers were asked to make suggestions on how to improve technical education in Ghana. In addition to suggesting more commitment from government, they cited the resource capacity base as being inadequate. The lack of infrastructure and teachers were the most significant complaints. Training materials and other facilities should be made available.

Assessment by Policy-Makers

Policy-makers assessed the existing resource capacity as inadequate. Facilities such as technical training establishments, equipment and library facilities were also rated as grossly inadequate, especially by engineering institution administrators (*Table 6.10*).

On the issue of funding of technical education, all respondents agreed that technical education was not being adequately funded. Other sources of funding, apart from government, were contributions from individual organizations and by students and parents. About 80 percent said there should be discrimination in favour of technical education in the annual national budget. Other views on funding are summarized in *Table 6.11*.

Table 6.8: Availability of Facilities as Assessed by Trainers

	% Rating					
Area	Excellent	V. good	Good	Fair	Poor	V. poor
Teaching materials	-	8.3	33.3	25.0	33.3	-
Laboratory facilities	-	-	35.0	58.3	16.7	-
Workshop equipment	-	8.3	16.7	41.7	16.7	8.3
Library facilities	-	-	33.3	41.7	16.7	-
Teaching staff/instructors	16.7	25.0	33.3	16.7	-	-
Technical support staff	8.3	25.0	41.7	16.7	8.3	-

Table 6.9: Resource Capacity Assessment by Graduates

% Rating					
Area	Excellent	V. Good	Good	Fair	Poor
Availability of study materials	12.5	18.8	43.8	25.0	-
Availability of equipment	12.5	6.3	25.0	43.0	12.5
Availability of teachers/trainers	12.5	37.5	50.0	-	-
Availability of classrooms	37.5	12.5	25.0	18.8	6.3
Availability of technical books	18.8	12.5	25.0	37.5	6.3
Effective use of equipment	-	31.3	37.5	31.3	-
Effective use of teacher/instructors	2.5	37.5	31.3	18.8	-
Effective use of study materials	12.5	31.3	37.5	18.8	-
Adequacy of funding	-	18.8	31.3	25.0	25.0

Table 6.10: Assessment by Policy-Makers

	Percentage Rating			
Area	Excellent	Adequate	Inadequate	Grossly Inadequate
Number of existing technical training establishments	-	-	40	60
Laboratory/workshop equipment in the establishment	-	-	60	40
Library facilities	-	-	40	60
Teaching staff/instructors	-	-	100	-

Table 6.11: Views of Policy-Maker, Funding of Technical Education

Area in favour of technical education	% Yes	% No
Annual national budget	80	20
Disbursement of the gold levy	100	-
Disbursement of district assembly common fund	100	-
Granting of loans by banks	100	-
Award of national/regional scholarships	100	-

Respondents were asked about their views on the training of technical teachers and instructors. All agreed that facilities for training technical teachers in the country were not adequate at present. Approximately 60 percent of the respondents subscribed to the opinion that the lack of industrial experience of the average technical teacher was a major handicap to performance. All felt that the government must develop a policy for the continuing education of technical teachers. Therefore technical teachers should be encouraged and assisted to spend short periods such as sabbatical leave or leave of absence in industry, funded by government.

Curriculum Structure and Content

Not all the polytechnics offer the same courses. However, all put together, part of the polytechnic education curriculum offers courses in the following areas: mechanical engineering, electrical engineering, civil engineering, metallurgy and chemical engineering.

These courses are offered up to higher diploma level. The course content includes mathematics, engineering graphics, construction, welding and foundry technology.

The University of Science and Technology, which offers engineering programmes, started in 1952 as a college under the University of Ghana to train basically science and engineering graduates. In 1963, the college was upgraded to the status of a university. For engineering education, the university offers programmes under two institutions i.e. the School of Engineering and the Institute of Mining and Mineral Engineering.

The programmes offered by the School of Engineering are mechanical engineering, electrical engineering, civil engineering, chemical engineering, geodetic engineering, and agricultural engineering. The Institute of Mining and Mineral Engineering (with its two campuses in Kumasi and Tarkwa) offers programmes in geological engineering, mineral processing and extractive metallurgy, materials science and engineering and mining engineering.

All programmes are geared towards B.Sc., M.Sc. and Ph.D. degrees. Diploma courses in the mineral sciences are still offered at the Tarkwa campus while all others are being transferred to polytechnics.

All B.Sc engineering programmes normally take four years. The period includes both practical work in industry (industrial training of at least six weeks a year) and theoretical and laboratory work. Many of the programmes have been prepared in consultation with the industry, external institutions and professional bodies.

The structure involves initial preparation of students, followed by detailed engineering principles, concepts and design. In addition to these, provision is also made for practical training both in the respective institutional workshops and laboratories as well as in the relevant industries.
The university operates on two semester-based, modular system, each semester running for 16-weeks. Course units are assigned to each course or practical work, from one to four credit hours per week. For each semester, a student is required to audit a number of courses to earn between 15 to 21 credit hours a week (i.e. at least five courses). The courses are either core or elective. Core courses are made up of basic courses, which all engineering students have to take, and courses specific to the discipline. For engineering students, elective courses have to be selected from the social sciences (about one per semester). There is an examination at the end of each semester. For a student to graduate, all required courses must be passed and a minimum of 145 credits hours must be obtained.

Management courses and entrepreneurial lectures are offered in the final year. Periodically, the programmes and course contents are reviewed and upgraded to ensure continued relevance to the industry.

Assessment of Course Structure and Course Content

Assessment by students

The students interviewed assessed the course structure and course content as shown in *Table 6.12.* The table shows that over 70 percent of the students were satisfied with the performance of their teachers as well as the variety and range of courses, theoretical content and relevance of courses offered. These areas were rated good to excellent. The students did not appear to be satisfied with the practicals, which involved laboratory work, fieldwork and projects. Over 50 percent rated these areas the poor to fair. The training technique was rated fair to good by over 70 percent.

It is therefore not surprising that only about 29 percent of the students interviewed were satisfied with their training. About 71 percent were not satisfied and stressed certain deficiencies, of which poor practical training and lack of modern facilities were prominent. The majority (81 percent) of the interviewees had done some industrial training and many of them found this to be useful to their programme.

Despite this drawback, 90 percent felt the training would ensure them good employment prospects. Many, (82 percent) looked forward to working in industry. Less than 10 percent thought of starting their own business. Only about 7 percent would like to work in the public service or in finance. The preference shown for industry is because about 43 percent felt that the training did not adequately prepare them to start their own business. They cited the lack of practical and industrial experience and the lack of entrepreneurial training as major constraints.

Assessment by Teachers and Trainers

Over 92 percent of trainers interviewed felt the current curricula for technical education are relevant to national need and that the curriculum prepares the student adequately for future employment. The main problems cited were poor attitude of students to their studies, the low practical content of the curricula and inadequate exposure of students to industrial practice. On the trainers, opinion on their students, many rated students in various areas as average (fair to good) as shown in *Table 6.13.*

Table 6.12: Assessment of Course Structure and Content by Students

	Percentage Rating				
Area	Excellent	V. good	Good	Fair	Poor
Performance of teachers	3.5	45.6	43.9	5.3	1.8
Variety/range of courses taught	16.1	37.5	42.9	3.6	-
Relevance of courses being taught	19.6	42.9	32.1	5.4	-
Theoretical content	26.8	57.1	16.1	-	-
Practical content	1.8	12.3	31.6	26.3	28.1
Training techniques	1.8	10.9	47.3	29.1	10.
Field work	5.3	8.8	24.6	29.8	31.9
Practical projects	3.5	19.3	33.3	35.1	8.8

Table 6.13: Assessment of Course Structure and Content by Teachers and Trainers

	Percentage Rating					
Area	Excellent	V. good	Good	Fair	Poor	V. poor
Attitude to their studies	16.7	16.7	58.3	8.3	-	-
Ability to relate theory to practice	-	16.7	50.0	33.3	-	-
Attitude to lab/workshop work	-	8.3	50.0	33.3	8.3	-
Use of library to enrich lectures	-	-	66.7	25.0	8.3	-
Initiative	-	16.7	75.0	8.3	-	-
Ability to use tools and equipment	-	16.7	41.7	41.7	-	-

Initiative was rated higher (75 percent as good) than others. The student's attitude was slightly above average whereas the use of library facilities, tools and equipment was found by trainers to be slightly below average. On related courses relevant to the engineering the trainers, views are summarized in *Table 6.14.*

Table 6.14: Responses from Trainers on Related Course Offering

Area	% Yes	% No
Management	66.7	25.0
Entrepreneurial	66.7	16.7
Technology policy	25.0	58.0

Despite the assertion by trainers that management and entrepreneurial courses were offered (66.7 percent), students felt these were lacking. Technology policy did not appear to feature in the curricula at all.

Many trainers (75 percent) said their students participated in industrial training. However, only about 50 percent of trainers participated in the supervision. As to the usefulness of the training, only 33 percent agreed to this. The majority did not respond or offer any suggestions for improvement.

Generally, teachers and trainers were of the view that the structure and content of the engineering programmes were appropriate to academic and national development. Trainers attributed the fall in educational standards to students' lukewarm attitude towards their studies and to lack of funds for provision of modern facilities.

Assessment by Graduates

As stated elsewhere, about 87 percent of graduates interviewed were satisfied with their training. Pressed further to give their opinion on the course structure and course content, similar views by students on the performance of teachers and on the practical content were expressed by the graduates. Many graduates simply assessed the practical content as fair but considered the theoretical content as either very good or excellent. On the structure, a few graduates thought that a year out for practical attachment would be beneficial to the training programme. Details of the responses of the graduates are summarized in *Table 6.15.*

Table 6.15: Views on Course Structure and Content by Graduates

	Percentage Rating				
Area	Excellent	V. good	Good	Fair	Poor
Performance of teachers	12.5	68.8	18.8	-	-
Variety/range of courses offered	31.5	31.5	37.5	-	-
Relevance of course offered	31.3	43.8	25.0	-	-
Theoretical content	25.0	37.5	31.3	6.3	-
Practical content	18.8	6.3	25.0	50.0	-
Training techniques	18.8	12.5	43.8	25.0	-
Fieldwork	25.0	6.3	37.5	25.0	6.3
Practical projects	6.3	43.8	31.3	18.8	-

The table shows that many graduates (over 90 percent) were satisfied with the performance of teachers, the variety and range of courses offered, the relevance of courses and the theoretical content. With the exception of practical projects which was rated as good to very good (over 70 percent), the practical content, training techniques and fieldwork were rated fair to good by 60 percent of the graduates. As further assessment would show, the majority of the graduates felt their training was adequate for their present jobs. About 75 percent did not need any additional training prior to starting their jobs.

Assessment by Employers and Supervisors

Employers did not comment specifically on the structure and content of technical education courses. However, from their comments on the performance of graduates, the following may be inferred as related to the structure and content of the curricula:

- Training is given to new technical employees to improve their technical competence, especially practical work, hence their suggestions to make technical education more practical.
- Courses more relevant to industry must be offered. No specific courses were, however, suggested.
- Non-technical courses such as communication skills must be offered to technical students. Many employers, however, seemed to be happy with the existing curriculum.

Assessment by Policy-Makers

On the question of the relevance of the current curricula for technical education to the needs of the country, about 40 percent said the curricula were not relevant, 20 percent agreed with the statement, while 40 percent offered no opinion. No opinion was given on what was considered relevant. However, the majority suggested that there must be an improvement in practical content of the curricula.

Post Qualification Training and Performance

The objective of training technical manpower is to provide the wheel that makes a country industrialized. The policy of industrialization with the application of science and technology is at the core of government policy as envisioned in the Draft National Science and Technology Policy and the Vision 2020 document.

The spectrum of industries is based on agriculture, health industry, government, private enterprises, the informal sector and Non Governmental Organizations (NGOs). Many engineering graduates enter industry, government and private organizations. The specific areas are industry:manufacturing (chemical, metal products), mining (gold, diamond, bauxite quarrying), metallurgical (aluminium and steel smelters), utilities (water, electricity), and shipping. The area also includes government: civil service (ministries, lands, survey departments), and public service (education).

Multinational companies, as a result of the current drive towards privatization, privately own the majority of industries. In the wake of the IMF conditionalities, government has divested itself of several state owned enterprises including the mining and metallurgical industries.

Under normal circumstances, industry produces below capacity for several reasons. Of late, the major constraint has been energy. The main source of energy, i.e. the Akosombo Dam (the dam the largest man-made lake in the world) is unable to supply enough power to the industries as a result of dwindling water levels. This situation is spawning an energy industry where thermal plants are being installed as the supplement, through government and private initiatives. Plants proposed to be in place by early 1999, were expected to make enough power available. The cost of energy is expected to go up and this is likely to affect industrial operations.

Already, in view of the decreased operations in much of the industry (about 60 percent capacity) some industries are encouraging part of the workforce to retire while recruitment of new staff is on the decline. Without adequate statistics, it is difficult to determine the proportion of new engineering graduates that eventually enter industry after the one-year national service.

Whether graduates in employment receive further training depends on the establishment they work in. Many employers find graduates qualified enough with the basic theoretical knowledge in the areas for which they have been employed. However, due to the varied nature of the employment in which engineering graduates find themselves, some internal arrangements are made to train them to suit specific assignments. In some cases, graduates are given completely new training, for example, marketing and management. The period of the training depends on the aims and objectives for which the training is carried out.

University departments organize courses for industry personnel from time to time. Professional associations also offer training as well as awareness seminars from time to time.

Assessment of Post Qualification Training and Performance

Assessment by Graduates

About 75 percent of the graduates interviewed completed their programmes before 1993. 80 percent had a bachelors degree and 20 percent had a masters degree. Many graduates interviewed (81 percent) felt the technical training they received was adequate for their jobs. About 75 percent did not receive any additional training from their employers; a few (about 12 percent) received some kind of on-the-job training ranging from two to six weeks. However, about 87 percent of the graduates had received some kind of on-the-job training or foreign training whether technical, management or both, during employment.

About 56 percent were satisfied with their present job. About 37 percent were not satisfied because of poor remuneration and poor work environment. Only 43 percent felt the monthly salary was commensurate with their qualifications, the majority (over 50 percent) felt otherwise. The graduates were pressed further to find out how well their technical education prepared them for their present jobs. The responses are summarized in *Table 6.16.* As may be seen from the table, the graduates felt that on the average (fairly well to very well) their technical education prepared them well for their present job in terms knowledge, work responsibility, career development, job challenges, job security, use of initiative, creativity and use of tools and equipment.

Table 6.16: Responses of Graduates on how Technical Education Prepared them for their Present Jobs

	Percentage Rating				
Area	V. well	Well	Fairly Well	Poorly	Very Poorly
Application of knowledge	31.3	43.8	12.5	-.	-
Work responsibility	25.0	43.8	18.8	-	-
Career development	25.0	37.5	18.8	6.3	-
Job challenges	18.8	31.3	37.5	-	-
Job security	12.5	31.3	37.5	-	6.3
Use of initiative	18.8	43.8	25.0	-	-
Creativity	31.3	37.5	18.8	-	-
Use of tool/equipment	18.8	25.0	37.5	6.3	-

As to whether the technical education of the graduates enhanced certain aspects of their jobs, the majority felt this was so (*Table 6.17*).

The graduates felt that their technical education enhanced the job opportunities, professional advancement, performance and promotion at work more than job satisfaction and marketability. Their training also enhanced monetary gains.

Table 6.17: How Technical Education of Graduates Enhanced Aspects of their Jobs

Area	% Yes	% No
Job opportunities	75	12.0
Monetary gains	43.8	31.3
Professional advancement 81.0	6.0	
Promotion prospects	69.0	13.0
Performance at work	75.0	13.0
Job satisfaction	56.0	19.0
Marketability	56.0	25.0

Assessment by Employers of Post Qualification Training and Performance

All respondents in the employer category were in the manager to senior manager positions. The companies they represented were all technical, employing between 100 and 2000 persons, the average number being about 600. Females represented about 10 percent of the number of employees in all the establishments. The majority of the technical staff had been recruited through advertisements (83 percent) and only about 17 percent through unsolicited application.

About 67 percent of the companies had in-house training schools. Those who did not have such schools had no plans to set them up. All the managers interviewed said their companies gave training to freshly recruited graduates, contrary to the views of majority of graduates who said they did not require prior training. Some of the training available included in-house, training elsewhere in the country or going for training abroad. The proportion of employees sent for technical after recruitment varied from 0 to 100 percent. However, the majority of the of the companies (fifty percent) usually trained about 20 percent of the recruited technical staff.
The major objectives of training varied but were usually sought to:

- diversify to employee's experience,
- broaden employees professional conduct,
- prepare employees for additional responsibilities,
- improve employees technical competence, and
- improve employees managerial competence.

Normally, on-the-job training was conducted. All the managers and supervisors interviewed had some technical training in engineering. The highest qualification was a masters degree but the majority had a diploma. Years of experience varied from seven to18. Many had been in a supervisory position for years. The number of workers supervised also varied from 10 to 400. Employers and supervisors were asked to give their opinion on the performance on the technical graduates they had supervised. Their views are summarised in *Table 6.18.*

The majority of the employers appeared to agree that the graduates they handled were in most cases above average. Performance on-the-job and practical knowledge were, however, given a lower, from fair to good.

On the basis of on-the-job performance, employers were asked to rate products from the various institutions. The responses are summarised in *Table 6.19.*

Here, again employers seemed to rate the performance from various training schools as average, with products from the universities being rated slightly higher.

Table 6.18: Performance of Technical Graduates as Seen by Employers and Supervisors

	Percentage Rating				
Area	Excellent	V. Good	Good	Fair	Poor
Technical Knowledge	-	50.0	50.0	-	-
Non-technical knowledge	-	16.7	50.0	-	-
Performance on the job	-	33.3	33.3	33.3	-
Practical knowledge	-	16.7	33.3	33.3	16.7
Initiative	-	16.7	50.0	16.7	-
Respect for authority	-	50.0	33.3	-	-
Willingness to accept responsibility 16.7	33.3	16.7	16.7	-	
Ability to adjust to working environment	-	33.3	33.3	16.7	-
Innovation	-	-	66.7	16.7	-
Working relationship	-	50.0	33.3	-	-

Table 6.19: Performance of Graduates from Various Institutions

	Percentage Rating				
Products	Excellent	V. Good	Good	Fair	Poor
Vocational training schools	-	33.3	-	50.0	-
Technical colleges	-	16.7	16.7	50.0	-
Universities	-	33.3	33.3	3.3	-

Engineering and Technical Education for Women

Demographic studies around the world show that women form over 50 percent of the world's population. In terms of education and job opportunities, however, women are greatly marginalized and disadvantaged. This situation is critical especially in the under-developed to developing countries in the south. In Africa, the situation is worse.

The problems start from early childhood where at the very initial stages of education, girls' enrolment is usually less than 50 percent. Myths, cultural and socio-cultural practices as well as economic considerations have usually culminated to form a barrier to the girl-child education. Parents thus decide that since it is the man who eventually caters for the family, sons should preferably be sent to school. This is usually the case in poor communities.

Along the educational ladder, females keep dropping out. Owing to physical and natural differences between men and women, the latter are usually considered weaker and therefore not cut out for strenuous work such as taking technical courses. Psychologically, therefore, by the time the girl is ready for a career, she is already diverted from technical and engineering courses.

Having noted this unfavourable bias against women, the UN has enacted policies to promote gender balance. With the UN declaration of the year of the child, Ghana has seriously taken up the issue of the girl-child education. The aim is to achieve 50 percent enrolment for females, within the shortest possible time, in all spheres of education. Science colleges are organised for females in secondary schools.

At university, efforts are being made to increase female enrolment. For an engineering based university such as the University of Science and Technology, Kumasi, females are being encouraged to take up engineering programmes. The current policy of the university is to maintain 20 percent female enrolment. In many of the engineering programmes, female enrolment is less than 10 percent.

Assessment of Engineering and Technical Education for Women

Female Engineering Education Views of Students

As outlined elsewhere, part of government policy on education is to achieve gender balance in enrolment, i.e 50 percent female and 50 percent male. In efforts to build this capacity, the University of Science and Technology has achieved 20 percent female enrolment.

While the 50 percent enrolment is achievable in areas such as the arts and social sciences, the number of females in engineering is less than 10 percent. Of the students interviewed, 89 percent were of the view that females should be encouraged to take up technical careers. The few who thought otherwise said that a technical career was too strenuous for females.

On the question of giving special incentives to encourage females to take up engineering education, 73 percent said yes. Some of the suggested incentives were special scholarships (55 percent), lower admission cut-off point (40 percent) or a combination of both. Only a small minority (2.5 percent) was against giving any incentives.

Technical and Engineering Education for Women Trainers' Views

Trainers believed, like others, that females needed to be encouraged to take up technical careers. About 92 percent of respondents were of this view. The minority said engineering or a technical career was too strenuous for a female. About 75 percent felt that females could take up any technical career.

On the question of giving special incentives to encourage females to go into engineering, 92 percent agreed. Some of the incentives suggested were a lower admission cut-off point, special scholarships and setting admission quota for females. The majority favoured lower admission cut-off points. About 67 percent disagreed that females were less able to cope with technical courses, compared to males. They said females were equally capable, the only problem being that only a few were admitted into engineering programmes because of the low number of female applicants. The root of this problem may lie in cultural and social attitudes. A good foundation is needed, therefore, to enable women go into engineering. Some of them are indeed better in the course than males.

Engineering Education for Women Graduates' Views

The majority of graduates interviewed (87 percent), like the students, felt that females must be encouraged to go into engineering careers. The few who did not share this view gave the reason that technical education and subsequent careers were too strenuous for females. About 62 percent said females could join any of the engineering programmes. However about 43 percent who felt that not all the programmes were suitable suggested chemical engineering. On females' ability to cope with engineering programmes, about 75 percent of the graduates agreed that females were capable. Their reason was that females were equal to men in all respects. Whereas the majority of students (73 percent) agreed on incentives to encourage females to take up technical and engineering education, only 44 percent of the graduates were in agreement. The majority (56 percent) said no. Those who agreed suggested the institution of special scholarships and admission quota as encouragement to the females.

Opinion of Employer and Supervisors on Technical and Engineering Education for Women

About 83 percent of employers thought that females should be encouraged to take up technical careers. Those who had contrary views did not assign any reasons. However, 33 percent of respondents felt that females should take up some technical careers, again citing chemical engineering. The majority (50 percent) were of the view that females could take up any of the engineering courses.

Asked whether females should be given special incentives to take up technical careers 83 percent said no; and only 17 percent said yes. In this case employers had contrary views to all other categories such as students, trainers, graduates and policy-makers who were positive on the provision of incentives to females. On the ability of females to cope with technical courses compared with males, 85 percent did not accept that females were less capable.

Opinion of Policy-Makers on Technical and Engineering Education for Women

All the policy-makers interviewed agreed that females should be encouraged to take up technical career. None agreed that only some technical careers be encouraged or that some were more suitable for females.

On the question of special incentives to encourage females to take up technical careers, all respondents agreed. Providing admission quota was favoured more than lower cut-off points or special scholarships. About 80 percent did not think that females were less able to cope with technical courses compared with males. The reasons were that what a man can do, a woman can also do. The problem as they saw it was that females were psychologically encouraged to pursue arts-based subjects in secondary school, thus diverting them from technical courses.

Conclusions and Recommendations

Policy on Engineering and Technical Education

The study revealed the following:

- Policy formation is poor and haphazard
- Adequate resources are not available to enable policies to work
- Implementation is poor.

It is recommended that persons with the requisite knowledge be involved with policy formulation. Clear guidelines need to be determined for effective implementation.

Resource Capacity

All interviewees agreed that the resource capacity for engineering/technical education is weak. The inadequacies are found in teaching staff, laboratory and workshop, classrooms, and funding. Efforts need to be intensified to provide the necessary resources. Without these, technical education do not have much impact on the national development efforts. Careful prioritising should make this achievable. All stakeholders in education must be involved in determining an effective mode of funding engineering education.

Course Structure and Content

The main deficiency identified was the lack of adequate practicals and industrial content of the curriculum; laboratory practical work is constrained by funding, and industry is not always willing to take on undergraduate for training.
It may be necessary to enact legislation to compel industry to offer industrial training to engineering students.

Post-qualification Training and Performance

Both graduates and employers agreed that engineering graduates are generally good. Their main drawback is in the practicals. However, training was provided to correct this and to equip the graduates with new skills. The performance of the graduates was judged to be good.

Engineering and Technical Education for women

The studies clearly show that females should be encouraged to take up engineering and technical education to enable them to overcome barriers that have hampered their progress in technical education. If need be, this is to be achieved by providing such incentives as admission quota for females, lower admission cut-off points, and special scholarships for females.

Chapter Seven

Country Report - Zimbabwe

Introduction

Zimbabwe is a republic located on the Southern Africa Region. It has a population of about 11.2 million and is situated between latitudes 15o331 and 22o241 south of the equator. The country covers an area of about 390,245 square kilometres. It attained its independence from Britain on April 18, 1980 after about 90 years of colonial rule.

Formal education in Zimbabwe begins at age five or six. The child spends seven years in primary school and is awarded seven certificates. If the child passes, he proceeds to junior secondary school, which lasts two years. There is a government examination at the end of two years and a junior secondary school certificate is awarded. The child thereafter proceeds to senior secondary level, which lasts another two years. G.C.E ordinary level (O - level) examinations are taken at the end of the second year in senior secondary level and if the child passes the 'O' level examination he is adjudged to possess the basic qualifications to proceed to tertiary institutions. These institutions include teachers training college, and technical colleges.

If the child does very well at 'O' level examinations, he can proceed to advanced level, which last two years. Success at the advanced level will qualify the student for admission to university.

The educational system in Zimbabwe has followed the traditional pattern adopted from the colonial government. This system was designed to produce human resource personnel who are at best literate but semi-skilled and thus can be employed as clerks or as government officials. The major weakness of this system is its emphasis on academic courses with little emphasis on technical or practical training. The result is production of a large pool of "unemployable" people.

Following the attainment of independence in 1980, the Zimbabwe government adopted an educational policy of "education for production". The policy attempts to ensure that each person leaving secondary school is equipped for productive work by emphasizing technical training below at the secondary school level. The details of this policy are presented below.

GovernmentPolicyRelatingtoEngineeringandTechnicalEducationpard

In Zimbabwe, the government policy relating to engineering and technical education can be discussed under two broad categories. The first relates to policies on primary and secondary education; the second relates to policies on tertiary education.

The Ministry of Education and Culture is responsible for setting up the government policy on primary and secondary education, while the Ministry of Higher Education and Technology is responsible for tertiary education policies. These two ministries were one until 1988 when the Ministry of Higher Education was hired from Ministry of Education. The Ministry of Higher Education was renamed Ministry of Higher Education and Technology in 1996 following government emphasis on the importance of technology in the economic development. The government has recently stressed the importance of technology in laying the foundation for industrial development and the growth of the country under the Zimbabwe Programme for Economic and Social Transformation (ZIMPREST) which was launched in 1998 as an economic development plan to be implemented for the ten-year period covering 1996 - 2006.

Primary Education Policies

Following the attainment of independence, the Government of Zimbabwe adopted a policy of free and universal primary education.

The broad goals of this policy were:

- To provide free and compulsory education and access to education for all children.
- To provide education for all, as a pre-requisite to all forms of national development.
- To develop national unity, equality and patriotism.
- To introduce “education with production” which entails the integration of the theory and practice into the children’s training.

The government’s implementation of these primary education policies led to a massive influx of children in primary schools. As a consequence, the number of primary school children rose from about one million in 1980 to approximately 2.5 million in 1990. Also during this same period, the number of primary schools rose from about 3000 to about 4500 while primary school teachers increased from 28,455 to 58,160.

Primary education in Zimbabwe is free in that no fees are paid by pupils. By 1998 primary education had become almost universal although the curriculum devoted little time to practicals or to technical subjects. The lack of practical education at the primary school level is, however, a major weakness of the present policy of introducing “education for production” at the primary level.

Secondary School Education Policies

Following the attainment of independence and the adoption of a policy of free and universal primary education which resulted in large numbers of unemployed primary school leavers, the Zimbabwe Government introduced some technical and vocational courses into the secondary school curriculum. This was to implement the policy of "education for production" at the secondary school level.

The policy of education for production adopted at secondary school level ensures that academic and practical subjects are treated equally at the Junior Secondary School Certificate level. The implication of this policy is that each pupil at the junior secondary level is expected to take two practical subjects which include courses such as woodwork, metalwork and technical graphics. The aim of this broad curriculum at junior secondary school is to instill into the pupils positive and favourable attitudes towards practical and technical subjects and thus bridge the gap between academic and practical knowledge.

Besides providing the facilities and opportunity to take technical subjects to junior secondary school level, the Ministry of Education in 1998 introduced some vocational and technical courses to be taken at senior secondary school level so that these courses can be offered at 'O' level examinations by the pupils. However, in terms of implementation, these technical courses were offered by a small percentage of secondary school leavers in the country.

In 1995, for example, out of about 200,000 students who sat for 'O' Level examinations, only about 16,000 took technical subjects. This represented only about eight percent of the population of school leavers for that year. We can therefore conclude that although the introduction of technical subjects into secondary schools has been a key policy of the government in terms of developing education with greater scientific and technical bias relevant to the needs of the country, the implementation of this policy lacks considerable impetus on the part of the government. The government needs to push harder for these technical courses to be taken by more students at senior secondary school or 'O' level. This is necessary to curb the rising tide of unemployment among secondary school leavers by preparing the students for the real world employment and thus making them more self-reliant and useful to the nation.

Tertiary Education Policies

The Ministry of Higher Education and Technology is responsible for setting up and designing policy on higher education. The Ministry is also responsible for planning, organizing and developing the entire Zimbabwe's higher education system. This includes teacher training, technical and vocational education at post secondary level, as well as professional training and development at university level.

During the first decade of independence, the broad aims of higher education in Zimbabwe included the following:

- To develop local human resources so as to make Zimbabwe as self-reliant as possible in its human resource requirements.
- To facilitate the transition from one level of education or training to another higher level, and to facilitate both the transfer and the development of a local technological capacity which will have international status.
- To establish and develop an educational system and the requisite infrastructure to meet the intellectual development aspirations of the individual in Zimbabwe.
- To equip every individual in Zimbabwe to be "self-reliant and more productive" - whether he be in the formal or informal employment sector of the economy.
- To establish and maintain uniform national academic award system.

The implementation of the above educational policies during the 1908 - 1990 period resulted in dramatic increases in the number of vocational training and technical colleges in Zimbabwe. For example, at independence there were only two technical colleges; the Harare Polytechnic and the Bulawayo Technical College. Since then, six technical institutions have been established. These include Kwekwe Technical College which has strong mining bias, the Kushinga Phikelela Technical College, with an agricultural focus, the Mutare, Gweru and Masivingo Technical Colleges and Zimbabwe Institute of Technology. Enrolment to these technical colleges increased rapidly and by 1990, total students enrolment in technical colleges was estimated at approximately 11,500. Some vocational colleges have also been established since independence. These include Msasa and Westgate vocational training centres.

As a means of providing the required staffing for the technical colleges and vocational training centres, the government established specialized Teachers Technical Colleges. These are Chinhoyi Teachers Technical College and the Belvedere Teachers Training College in Harare.

It should be pointed out also that the number of teacher training colleges increased from six to 15 for the period 1980 to 1990, while student enrolment in teacher training colleges rose from 3062 to about 16,000.

The emphasis on technology as a key element of industrial growth and economic development led to the renaming of the Ministry of Higher Education as the "Ministry of Higher Education and Technology" in the year 1996.

The Higher Education policy under the new ministry puts considerable emphasis on technology as summarized in the Zimbabwe programme of economic and social transformation (ZIMPREST)

i. Human resource development is the major policy for higher education and it is a "*sine qua non*" for industrial development of Zimbabwe. The policy recognizes that, although Zimbabwe's workforce is one of the best in the educated in the southern Africa region, there are still major gaps and shortages of technicians, engineers and scientists in the country. Under the policy, in the University of Zimbabwe, the National University of Science and Technology, polytechnics and technical colleges, vocational schools and teachers colleges are required to produce manpower with the skills needed by industry; and there must be close consultation with industry on training courses and requirements for the various skills.

ii. An important component of this policy requires industrialists in the country to expand on-the-job training for their staff and also resources under the Zimbabwe Manpower Development Fund to train students on industrial attachment so as to enhance the practical aspect of their skill development.

iii. This policy makes provision for opportunities for entering into technological transfer agreements with other countries.

iv. A major step in the implementation of this policy was the establishment of the Scientific and Industrial Research and Development Centre (SIDRC), which was set up under the Research Act of 1986 for the Research Council of Zimbabwe. The main objective of SIDRC is to promote Research and Development (R&D) needs of industries in the country.

It can be observed that the main focus of these policies is to ensure that higher educational institutions in the country produce the required manpower needed in the industry and other sectors of the Zimbabwean economy. At present, there are four universities in Zimbabwe (two private and two government financed). The university of Zimbabwe and the National University of Science and Technology are government financed. Solusi University and Africa University are private. The combined enrolment for the four universities was estimated to be over 12,000 in 1998.

A major component of technical education policy is the important contribution of industry to higher education training. Students in technical colleges and universities offering engineering courses undertake industrial attachment programmes in various industries in the country. The Zimbabwe Manpower Development Fund (ZIMDEF) can be drawn from various industries to meet the cost of attaching students for industrial internship.

In summary, the current educational policy for Zimbabwe places considerable emphasis on “education for development” and on “education for protection”. The emphasis is on production of manpower that would possess the skills needed by industry and other sectors of the economy.

Assessment of Government Policy on Engineering and Technical Education in Zimbabwe

The report in this section is based on a field survey of various sectors of Zimbabwe’s economy. The survey was on students at the University of Zimbabwe and the National University of Science and Technology, Bulawayo. The assessment also carries the viewpoints of engineering graduates. Also included is the opinion of teachers and trainers, employers and supervisors, and policy-makers in industry and at the universities.

Assessment by University Students

Approximately 62.3 percent of students interviewed indicated that the country's policy on technical and engineering education can be classified as good to excellent. Less than half of the respondents (37.7 percent), however, ranked the policy at between poor and fair.

The students' suggestions to improve the present policy on technical/engineering education include:

- the need to incorporate more practical courses in the education curriculum.
- better funding of the programme.
- provision of adequate equipment and facilities.
- early introduction of technical courses (at primary school level)
- training for self-employment including development of entrepreneurial skills.

Student assessments of the pace of technological development in Zimbabwe reveals that about 46 percent of the students found the pace of technological development in the country to be good, while 54 percent found it to be fair to poor. The reasons advanced by the students for this poor pace of technological development include:

- the fact that most technologies are imported and therefore not developed locally
- poor funding by the government
- poor research and development
- poor technology appreciation on the part of some policy-makers.

Assessment by University Graduates

The graduates' assessment of the technical and engineering education policy in Zimbabwe reveals that 57.9 percent of those interviewed rated the policy as good to excellent, while 42.1 percent rated the policy as poor to fair. This was slightly lower than the rating by the students and the following suggestions were offered by the graduates to improve the present policy on technical and engineering education in Zimbabwe.

- the need for more practicals to be incorporated into the curriculum
- more funding of technical institutions
- better focus on technological development by policy makers in the country.

Graduates' assessment of the pace of technological development in Zimbabwe reveals almost similar rankings as those of the students with about 42 percent of the graduates ranking the pace of technological development in the country to be good; while about 58 percent ranked it to be only fair to poor. Lack of funding and appropriate technological policies were cited by the graduates as being responsible for the slow pace of technological development in Zimbabwe.

Suggestions made by the graduates to improve the pace of technological development include better funding of technological education programmes, particularly at the university and industry level, more activities on the part of SIDRC, and more research on development of appropriate technology for the country.

Assessment by University Teachers and Trainers

Interviews obtained from teachers and trainers reveal that only about 31.8 percent of the teachers and trainers were aware of government policy on technical education. About 68.2 percent were not aware of any government policy on technical education.

The trainers who were aware of government policy indicated that it had influenced their teaching and curriculum by the introduction of new courses and more bias towards practicals. Others have noticed any influence of government policy on their curriculum.

On policy formulation, only about 13.6 percent of the trainers and teachers had participated in the formulation of government policy on technical education. Those who participated indicated that their input was in setting syllabi for polytechnics and technical colleges. Suggestions made by trainers and teachers for improving government policy on technical education include:

- more co-operation between the universities and industry
- the need to involve all stakeholders in policy formulation
- the need for better government funding
- the need for industry to contribute more funds
- the need to set up a special body to co-ordinate technical education policy.

Assessment by Employers and Supervisors

Survey among employers indicates that 50 percent of the employers participated in the planning of technical education in Zimbabwe. Their participation is in serving on advisory committees of faculties and departments of engineering. They also provide facilities for practicals and industrial training to students in polytechnics and universities. All those who do not participate in the planning of technical education indicated that they would like to be involved. The employers identified the following problems of technical education in Zimbabwe.

- lack of sufficient industrial support
- lack of equipment and infrastructure
- lack of entrepreneurial skills development
- lack of field exposure on the part of students.

The following suggestions were made by employers to help government and institutions improve on technical education in Zimbabwe:

- the need for lecturers and trainers to be familiar with local industries
- the need to expose the students to real world situations in industries
- the need to extend the period of internship to give students more exposure
- provision of more training materials and facilities at the institutions.

Assessment by Policy-Makers

The policy-makers interviewed included Permanent Secretaries and the Director-General as well as chief executives of government parastatals. They also included university vice-chancellors, deans of faculties, and principal officers of the University of Zimbabwe and the National University of Science and Technology. They also included the Chief Executive of the Zimbabwe Institution of Engineers.

About 33.3 percent of the policy-makers indicated that they are involved in policy formulation, while only 20.0 percent indicated that they are only involved in policy execution. Approximately 46.7 percent were involved in both policy formulation and policy execution.

Furthermore, 46.7 percent of those interviewed said that the Zimbabwe technical education policy has been in place between 10 and 20 years, while 13.3 percent indicated that the technical education policy has been in place for between six to 10 years. Approximately 33.3 percent indicated that they had no knowledge of how long the policy had been in place, while 6.7 percent indicated that they were not aware of its existence. Approximately 73.3 percent of those interviewed considered the policy on technical education inadequate. They identified deficiencies as:

- inadequate industrial experience for trainers
- inadequate personnel and infrastructures at training institutions
- inadequate funding of the programme
- training not geared to meet specified manpower target needs of the country.

The results also show that the main thrust of government policy on technical education is to train manpower for economic development. The thrust also includes building up the human resource capacity for the country.

Respondents were asked to rate the achievements of some specific objectives of the national policy on technical education. The results are presented in *Table 7.1*. It can be observed from the table that about 73.3 percent of the respondents rated as fair to good the achievement of the objective of technical teachers. However, about 86.7 percent of the respondents also rated as poor to very poor the achievement of the objective of introduction of elementary technology into school curriculum as early as possible. The main reason for this poor rating is that teaching of elementary technology has not been emphasized at primary school level in Zimbabwe. The achievement of the objective of establishing multi purpose vocational centres and technical colleges in every province in Zimbabwe was ranked as fair to good by about 80 percent of the respondents. Only about 46 percent rated as fair to good the attainment of the objective of teaching science and technology in an integrated manner in Zimbabwe schools. About 93.3 percent of the respondents also rated as fair to poor the attainment of objective of providing well-equipped workshops for junior secondary schools and technical colleges. This poor rating is consistent with the fact that well-equipped workshops are still lacking in most of these institutions in Zimbabwe.

The respondents' opinion as to whether their establishments have available statistics on certain areas of technical manpower in the country is summarized in *Table 10.2*. An observation of the table reveals that 93.3 percent of the respondents have no statistics on current population and mix of technical manpower in the country. Only 33.3 percent have statistics on the projection of the country's technical manpower needs and 66.7 percent without this information, thus making future manpower planning difficult for their establishments. The statistics of training establishments were available to about 66.7 percent of the respondents, while projection of future requirements of technical training establishment are available to only 26.7 percent of the respondents. This makes planning for future technical training relatively difficult for most of the respondents.

Table 7.1: Policy Makers' Rating of National Policy on Technical Education in Zimbabwe

Objectives	Percentage Rating					
	Excellent	V. good	Good	Fair	Poor	V. poor
Training of technical teachers	6.7	13.3	6.7	46.7	20.0	6.7
Early introduction of elementary technology in the school system.	-	-	13.3	20.0	40.0	26.7
Introduction of skill-forming technical courses into the secondary schools.	-	6.7	6.7	46.7	26.7	13.3
Restructuring of technical curricula to broaden the scope and focus on national needs.	-	6.7	20.0	26.7	13.3	33.3
Establishing multi-purpose vocational and technical schools in every province.	-	20.0	26.7	33.3	6.7	13.3
Integrating the teaching of science and technology to promote appreciation.	-	6.7	20.0	20.0	33.3	20.0
Provision of well-equipped workshops for junior secondary schools and technical colleges.	-	-	6.7	13.3	60.0	20.0

Source: Field Survey 1998

Table 7.2: Policy Makers' Views on Availability of Reliable Statistics for Technical Training and Manpower in Zimbabwe

Area	Percentage of Respondents	
	Yes %	No %
Statistics on current population and mix of technical manpower in the country.	6.7	93.3
Statistics for projections of the country's technical manpower.	33.3	66.7
Statistics of existing technical training estblishments in the country.	66.7	33.3
Projection of future requirements of technical training establishments.	26.7	73.3

Source: Field Survey, 1998

In the absence of reliable statistics the respondents identified the following guiding principles in making their contribution to the formulation of national policy on technical education:

- there ought to be focus on areas of comparative advantage and train people in these areas
- technical training should emphasize practicals
- adopt a clear policy for the country
- universities should be represented in the formulation of the technical education policy
- consult with industries and other employers in designing national technical education policy.

Resource Capacity for Engineering Education in Zimbabwe

Since the focus of attention in this study is on tertiary education, we will endeavour to assess the resource capacity for polytechnics or technical colleges in Zimbabwe.

There are eight government funded technical colleges (including two polytechnics – the Harare Polytechnic and the Bulawayo Polytechnic). The technical colleges offer courses in specialized areas leading to the award of National Diploma or Higher National Diploma. For the period 1982 to 1987 the Harare Polytechnic and Bulawayo Polytechnic offered B. Tech degree programmes initially on their own, but since 1988 under the University of Zimbabwe.
There are currently four universities in Zimbabwe: the University of Zimbabwe at Harare, the National University of Science and Technology at Bulawayo, Africa University at Mutare and Solusi University near Bulawayo.

Only the University of Zimbabwe and the National University of Science and Technology offer courses in engineering.

The University of Zimbabwe evolved from the former University College of Rhodesia and Nyasaland, which was established in 1957 to offer degrees of the University of London. The University of Zimbabwe has a Faculty of Engineering, which was established in 1974. This faculty presently has six departments: Civil Engineering, Electrical Engineering, Mechanical Engineering, Metallurgical Engineering, Mining Engineering, and Geo-informatics and Surveying.

Civil, Electrical and Mechanical Engineering are in inaugural departments. Mining, Metallurgy and Surveying were established in 1985. The Faculty offers B.Sc. Engineering Honours degree programmes in the five specialized areas of engineering. These programmes normally take four years to complete. However, the Department of Mining has introduced a one-year industrial attachment program thus making its degree programme last five years. In addition, the faculty offers a B.Sc. Surveying Honours degree programme which takes four years to complete.

The six departments in the Faculty of Engineering at the University of Zimbabwe enrolled about 650 under graduate students in 1997. Also, over the years, the faculty has produced over 1000 engineers for the country.

The faculty is expanding its postgraduate training program. By 1997, it had 20 M.Sc. students, and five diploma students in 1998. The M.Sc. programs are offered in the Department of Mechanical Engineering, the Department of Electrical Engineering and Surveying. The M.Sc. programme covers two years on full time basis. A post-graduate diploma programme is offered in Land and Geographic Information Systems by the Department of Surveying. This programme takes about 12 months on a full-time basis.

The National University of Science and Technology was established in 1991. The university offers five years Bachelor of Technology degree programmes in Electronics Engineering, Industrial Engineering and Water Engineering.

The students under B. Tech. degree programmes are required to spend one year in industry during their study.

Financial of Engineering Programmes

Since the attainment of independence in 1980, the national budget for education has consistently been the largest item of expenditure and this is a reflection of the importance government attaches to education. Expenditure on education rose from about $200 million in 1980 to $841 million in 1988/89. Since then, educational budget has continued to take the largest share of the budget. Financing of engineering education programmes is done primarily by the Zimbabwean government through the Ministry of Higher Education which provides funds in the form of grants and loans to technical colleges, polytechnics and the two government funded universities. These tertiary institutions also receive financial support from NGOs to finance specific programmes. For example, the British Overseas Development Administration (ODA) provided about 2.2 million pounds sterling to support teaching and academic programmes of the Faculty of Engineering at the University of Zimbabwe for the period 1985 to 1994.

Table 7.3 which summarizes the budget of the University of Zimbabwe presents a clearer picture of these finances. It can be observed from the table that government's allocation to the university has constituted about 80 to 85 percent of the sources of funding to the university. The university has therefore been increasingly dependent on government grants and subventions. Other sources of funding such as academic fees and specific donations from donors constituted an insignificant percentage of the total funds available to the University of Zimbabwe. We should note the upward trend in total income and expenditures of the university. This may be attributed to the rising cost of financing higher education in country.

Table 7.3: Budget of the University of Zimbabwe (1990 - 1994)

Item Z$000	1994/95 Z$000	1993/94 Z$000	1991/92 Z$000	1990/91
Income				
Government-Grant Recurrent	294 000	192 087	92 000	76 071
Government Grant Capital 19 710	21 560	8 680	14 89	
Funds for Specific Purposes	44 807	55 714	20 702	9 506
Academic Fees	18 998	11 491	6 495	5 846
Other income from Investments	8 512	9 725	4 441	3 511
Other	693	636	429	373
Total Income	**386 720**	**291 215**	**132 747**	**110 199**
Expenditure				
Recurrent	297 899	230 963	117 430	91 582
Capital	23 603	24 126	8 500	9 116
Funds for Specific Purposes	33 496	55 197	20 667	9 086
Equipment	2 252	2 989	4 593	352
Total Expenditure	**457 250**	**313 275**	**151 190**	**110 148**

Source: University of Zimbabwe Audited Accounts

Table 7.4 presents the findings from this study. It can be observed from the table that total recurrent and capital expenditures of the Faculty of Engineering at the University of Zimbabwe has risen from about $5 million in 1990/91 to about $13.36 million in 1993/94.

Table 7.4: UZ Faculty of Engineering Expenditure Compared with Total UZ Expenditure (1990 - 94)

Year	Total UZ capital Exp. * (Z$'000)	Total UZ recurrent Exp. (Z$'000)	Total UZ Exp. Exp. (Z$'000) (Z$'000)	UZ faculty of Eng. Exp. (Z$'000) (Capital)	UZ faculty of Eng. Exp. (Z$'000)	UZ Faculty recurrent of Eng. total Exp. UZ (%)	UZ Faculty of Eng. as %of total Exp.
1990/91	18,566	91,582	110,148	1,672	3,388	5,060	4.59
1991/92	33,760	117,430	151,190	1,823	4,228	6,051	4.00
1993/94	82,312	230,963	313,275	788	12,572	13,360	4.26
1994/95	159,351	297,899	457,250	894	11,546	12,440	2.72**

* Capital Expenditure covers equipment and funds for specific capital items.
** This is low compared with students' distribution of 10.8 percent for Engineering as compared with total.

Source: University of Zimbabwe Audited Accounts

When these figures were compared with total expenditures for the university, it was observed that aggregate expenditure for the Faculty of Engineering represents only about 4.59 percent of total university expenditure in 1990. It declined to about 2.72 percent during 1994/95. This decline in the percentage of funds allocated to the Faculty of Engineering is a reflection of gross under-finding, in spite of the top priority given by government to science and technology in educational programmes. It should also be noted that equipment for the Faculty of Engineering is more expensive than for non-technical faculties and that the engineering students who represent about 10.8 percent of total student population received only 2.72 percent of total expenditure during the 1994/95 year. This distribution is, therefore, not very equitable. However, the valuable contribution of the British Government through the ODA helped the Faculty of Engineering to provide the necessary financial support in terms of equipment and during this period.

Besides the budget allocation to Engineering, it is necessary to also estimate the unit cost per engineering student. *Table 7.5* summarizes the findings for the average engineering student at the University of Zimbabwe for the 1993/94 year.

Table 7.5: Unit Cost per Graduate, Faculty of Engineering, UZ (1993/94)

Unit Cost	Cost per student per (Z$)	Cost per Graduate* (Z$)
Recurrent Unit Cost Recurrent & Capital Unit Cost	22903 26,576	106449 123,578

* Assumes average time taken to produce a graduate is 4.65 years, taking into account the drop-outs and repeaters.

Source: ODA Report, Faculty of Engineering, UZ, 1996

Table 7.5 indicates that the unit cost per student was estimated as $26,576 for the 1993/94 period. This was significantly higher than the figure for the 1992/93 period which was estimated by ODA as $16,700 per student per year. The differences in the unit cost for the period represent the rising cost of training engineering students at the university.

At the Harare Polytechnic, the recurrent unit cost per student for the 1993/94 period was estimated at only $9500. This figure is considerably less than the recurrent unit cost of $22,903 estimated for the Faculty of Engineering student for the same period.

The last column of *Table 7.5* reveals the average cost of training an engineering graduate which has been estimated at $123,578. When converted to foreign currency this turns out to be about $12,700. This cost can be compared with the cost of training an engineering graduate in UK which was estimated by ODA at $42,000 for the period 1993/94. In conclusion, although training engineers in Zimbabwe can be expensive, it is still far relatively cheaper and more cost-effective than training them in Europe.

Student Enrolment and Production of Graduates

A major index of resource capacity for engineering education is to look at the student enrolment for engineering courses as well as the production of engineering graduates by the Faculty of Engineering. Unfortunately these data are only available for the University of Zimbabwe, which has been the main producer of engineering graduates in Zimbabwe for the past two decades. *Tables 7.6* and *7.7* present the available enrolment data for the University of Zimbabwe - Faculty of Engineering. It can be noted from *Table 7.6* that student enrolment has increased from less than 200 in 1982 to about 652 in 1994. This is an increase of more than 300 percent within a twelve-year period. The significant rise in student enrolment is partly due to the establishment of three new departments (Metallurgy, Mining and Surveying) in 1985.

Table 7.6: UZ Faculty of Engineering Student Enrolment (1982 - 1994)

Year	Part 1	Part 2	Part 3	Part 4	Total
1982	90	52	32	10	184
1983	97	59	37	28	221
1984	98	54	57	39	248
1985	124	75	53	51	303
1986	151	104	71	52	378
1987	184	119	99	71	473
1988	192	186	105	91	574
1989	174	189	153	95	611
1990	181	170	156	134	641
1991	183	157	159	142	641
1992	167	171	144	152	634
1993	175	161	175	149	660
1994	175	164	161	152	652

Source: Faculty of Engineering, UZ Students Records

An enrolment situation by various departments in the Faculty of Engineering is presented for the year 1993 in *Table 7.7*. It is apparent from the table that Civil Engineering has the largest student enrolment, followed by Electrical Engineering and then Mechanical Engineering. The fact that Civil Engineering has the largest is typical of developing countries where infrastructural development is dominant compared to, say, manufacturing.

Table 7.7: UZ Faculty of Engineering Students Enrolment by Departments (for 1993)

Department	Part 1	Part 2	Part 3	Part 4	Total
Civil Engineering	53	40	52	43	188
Electrical Engineering	37	32	35	35	139
Mechanical Engineering	27	28	37	32	134
Metallurgy	18	17	20	17	72
Mining Engineering	25	23	18	13	79
Surveying	15	11	13	9	48
Total	75	161	175	149	660

Source: UZ Faculty of Engineering Students Records

The engineering graduate output for the university of Zimbabwe is summarized in *Table 7.8*. Between 1982 and 1994, the Faculty of Engineering produced 1123 graduates.

Table 7.8: UZ Faculty of Engineering Graduate Output*

Year	Civil Eng.	Electrical Eng.	Mechanical Eng.	Metallurgy	Mining Eng.	Surveying	Faculty Total
1982	7	2	1	-	-	-	10
1983	7	14	5	-	-	-	26
1984	15	13	8	-	-	-	36
1985	17	21	14	-	-	-	52
1986	17	18	15	-	-	-	50
1987	29	27	15	-	-	-	71
1988	35	27	15	4	3	3	87
1989	29	27	19	8	8	3	94
1990	45	44	15	9	9	10	132
1991	52	34	24	7	10	10	137
1992	56	36	24	12	13	10	151
1993	41	35	23	16	6	8	129
1994	55	33	18	20	8	13	147
Total	405	331	196	76	58	57	1123

* This excludes Bachelor of Technology degrees graduates

Source: Faculty of Engineering, UZ

The graduates can be categorized into the various specializations as follows:

- Civil engineers 405·
- Electrical engineers 331
- Mechanical engineers 196
- Metallurgical engineers 76
- Mining engineers 58
- Surveying graduates 57

Teaching and Support Staff

Teaching and support staff constitute a major component of the resource capacity for promoting engineering education in Zimbabwe. The academic staff give lectures and instructions to engineering students. These lectures cover both theories and practicals. Most teaching staff at the universities are highly trained personnel who with post-graduate degrees. The academic staff position at the University of Zimbabwe is presented in *Table 7.9* for the period December 1994.

Table 7.9: University of Zimbabwe's Academic Staff Situation by December 31st 1994

Faculty	Established Post	In Post	Vacancies	Vacancies %
Agriculture	69	67	2	2.9
Arts	116	106	10	8.6
Commerce	42	271	53	5.7
Education	104	88	16	15.4
Engineering	88	77	11	12.5*
Law	28	23	5	17.9
Medicine	200	138	72	31.0
Science	162	129	33	20.4
Social Studies	85	79	6	7.1
Vet. Science	45	34	11	24.4
Other	-	-	-	-
Total	939	768	171	18.2

Source: University of Zimbabwe's Annual Report 1995

The figures in this table show that in 1994 the Faculty of Engineering had 88 established academic staff positions out of which 77 were filled while 11 were vacant. During the period, about 25 percent of the filled positions were occupied by expatriate staff on contract. However, this represents a significant improvement in localization of staff and is a result of a fairly successful staff development programme of the late 1980s and early 1990s supported by the British government. The vacancy rate in the Faculty of Engineering was estimated as 12.5 percent and this compared less favourably with such faculties as Agriculture, Social Sciences and Arts but more favourably with Medicine and Commerce.

The academic staff require support staff to effectively conduct teaching. Support staff can be categorized into technical, clerical and administrative. The technical staff include technicians of various grades required for the laboratory and workshop technical work. They also include journeyman and assistant technicians. The administrative staff include the administrative officers, secretaries, clerical officers and administrative assistants.

The number of support staff in relation to academic staff for the Faculty of Engineering at the University of Zimbabwe for the year 1998 is presented in *Table 7.10.* It can be observed from this table that in 1998, the academic staff in the faculty was estimated as 68. This compares with a support staff of 24 administrative personnel, and 44 technicians. The total number of support staff was also 68. This support staff was relatively high but it is necessary to have adequate support staff to be able to run the laboratories and workshops engineering curriculum.

Table 7.10: Academic and supporting staff for the Faculty of Engineering, University of Zimbabwe as of August 1998

		Supporting Staff	
Department	Academic Staff	Administrative	Technical
Faculty Office	3	7	15
Civil Engineering	11	6	7
Mechanical Engineering	16	3	5
Electrical Engineering	15	4	3
Metallurgical Engineering	9	2	6
Mining Engineering	7	1	1
Surveying	7	1	7
Total	68	24	44

***** The Dean and Deputy are not included in this figure as they are accounted for in their departments
Source: Faculty of Engineering, UZ

Facilities: Laboratories, Workshops and Libraries

Facilities such as laboratories, workshops and libraries are required for effective training of engineering students. The availability of these facilities varies from one institution to another but it can be observed that most polytechnics and technical colleges in the country have some form of laboratories and workshops for training purposes. The facilities available at the Faculty of Engineering, University of Zimbabwe can be listed as follows:

- Faculty of Engineering Computer Aided Learning (CAL) Laboratory
- Faculty of Engineering Workshop
- Timber Research Laboratory for the Department of Civil Engineering
- Heavy Current and Light Current Electrical Engineering Laboratory
- Students Training Workshop
- Mining machinery and equipment for teaching at the Department of Mining Engineering

The University of Zimbabwe Library has adequate engineering books, journals and other teaching and research materials and students access to other regional libraries through the Internet. Other facilities available at the university include the laboratory of the Institute of Mining Research located at the university campus in the Faculty of Science.

Assessment of Resource Capacity for Engineering Education in Zimbabwe

Assessment by University Students

Students' assessments of resource capacity are summarized in*Table 7.11.* The table shows that the majority if the students (68.7 percent) assessed funding or engineering education to be relatively poor. The inadequacy of funding affects all aspects of the programme ranging from meeting other resource needs to execution.

Table 7.11: Students' Assessment of Resource Capacity for Engineering Education in Zimbabwe

	Percentage Rating				
Resource Factor	Excellent	V. Good	Good	Fair	Poor
Resource supply					
Adequacy of funding	4.3	7.8	19.1	39.1	29.6
Availability of teachers/instructors	13.9	40.0	27.1	16.5	2.6
Availability of classroom	35.7	23.5	15.7	14.8	14.4
Availability of equipment	4.3	7.8	28.7	33.9	25.2
Availability of study materials 4.3	15.7	38.3	27.8	13.9	
Availability of technical books and journals in the library	6.1	17.4	31.3	27.0	18.3
Resource Use					
Effective use of teachers/instructors	11.3	34.8	42.6	8.7	2.6
Effective use of equipment	7.9	23.7	38.6	21.9	7.9
Effective use of study materials 9.7	38.1	42.5	9.7	0.0	

Source: Field Survey, 1998

fThe supply and availability of teachers and instructors for engineering programmes were assessed by 80.9 percent of the students to be good and very good while availability of classroom was assessed by about 75 percent of the students to be good to very good.

Availability of equipment was, however, adjudged by about 59 percent of the students to be poor to fair. This might explain why the students ranked the practical aspects of the programme to be inadequate.

About 70 percent of the students also ranked as good to very good the effective use of available equipment for the programme. The majority (90.3 percent) ranked as good to very good the effective use of study materials and over 88 percent ranked as good to excellent the use of teachers and instructors. Students' assessment of library facilities shows that about 45 percent of them found the supply of technical books and journals in the library to be only poor to fair. This is important for future improvement in the engineering education programme.

Assessment by Engineering Graduates

Approximately 63.2 percent of the graduates interviewed were satisfied with the training they had at the university level. Those who were not satisfied (36.8 percent) indicated that the major weakness of the existing training programme is its poor practical orientation which can be related to poor resource availability for the engineering programme.

The specific responses of the graduates in their assessment of resource capacity of the engineering education programme are summarized in *Table 7.12*.

Table 7.12: Assessment of Resource Capacity by Engineering Graduates in Zimbabwe

	Percentage Rating				
Resource Factor	Excellent	V. Good	Good	Fair	Poor
Adequacy of funding	5.3	21.1	31.6	31.6	10.6
Availability of teachers/instructors	15.8	42.1	26.3	15.8	-
Availability of study materials 10.5	15.8	26.4	36.8	10.5	
Availability of equipment	10.5	26.3	15.8	42.1	5.3
Availability of classrooms	42.1	36.8	15.8	5.3	-
Availability of reading materials in the library (technical books)	15.8	10.5	21.1	47.4	5.3
Effective use of equipment	-	31.6	42.1	26.3	-
Effective use of teachers/instructors	-	57.9	36.8	5.3	-
Effective use of study materials	5.8	36.8	47.4	--	

Source: Field Survey, 1998

The table shows that 37 percent of the graduates assessed the funding of the engineering programme to be poor/fair, 47.4 percent of the graduates assessed the availability of study materials to be poor/fair, while 52.6 percent assessed the availability of technical books and journals in the library to be poor/fair. On the positive side, about 84 percent of the graduates assessed the supply of teachers and instructors to be good to very good. Availability of classroom was assessed by 95 percent of the graduates to be good to very good, while 47.4 percent assessed availability of equipment to be fair to poor. Over 94 percent of the graduates assessed the use of teachers and instructors as good to very good and about 74 percent assessed the effective use of equipment as good to very good. All the respondents (100 percent) assessed as good to very good the effective use study materials for the programme. In summary, the critical constraints to the programme as by the graduates are funding, equipment and availability of technical books in the library. The suggestions of graduates for improving the training programme include more practicals, better funding and more focus on technology development by the policy-makers in the country.

Assessment by Teachers and Instructors

All the 22 teachers and trainers interviewed specialists in various fields of engineering. Most of them (81.8 percent) had university education with about 36.4 percent having doctorate degrees and about 31.8 percent with master's degrees. About 95.5 percent of the trainers and teachers had industrial experience prior to taking up their teaching job the majority of them (68.2 percent) indicated that personal interest had been the motivating force for teaching, while money and job security were of secondary importance. The facilities listed by trainers as being available for their training included laboratory, lecture halls, computers, and other equipment.

The trainer's assessment of the various facilities is presented in *Table 7.13.* It can be observed from the table that the majority of the trainers (about 68.2 percent) assessed laboratory and workshop facilities to be inadequate.

Table 7.13: Teacher and Trainers' Assessment of Resources and Facilities for Engineering Training in Zimbabwe

	Percentage Rating			
Resource/Facility	Excellent	Adequate	Inadequate	Grossly
Inadequate				
Teaching materials	9.1	50.0	40.9	-
Laboratory/ workshop facilities	-	31.8	59.1	9.1
Library facilities	4.5	59.1	31.8	4.5
Teaching staff/ instructors -	36.4	50.0	13.6	
Technical support staff	4.5	54.6	31.8	9.1

Source: Field Survey, 1998

Also, about 63.6 percent of the trainers assessed the existing teaching staff to be inadequate. However, about 59 percent of the trainers assessed the technical support staff to be adequate, while about 41 percent assessed the technical support staff to be inadequate. Library facilities were also assessed to be adequate by about 63.6 percent with about 36.4 percent of the trainers assessing library facilities as inadequate. It is apparent from this assessment by the trainers that some of the training facilities are at present inadequate.

Assessment by Employers and Supervisors

When employers were requested to identify problems of technical and engineering education in Zimbabwe they cited lack of adequate resource capacity, including workshops and laboratories. They also cited lack of training materials and inadequate and technical support staff.

Assessment by Policy-MakerspardAssessment by Policy-Makers

Most of the policy-makers interviewed indicated that the existing resource capacity is inadequate for engineering education in the country. The policy-makers were asked to assess the specific resource capacity in terms of number of training establishments, adequacy of laboratory and equipment facilities, library facilities, and teaching staff and instructors. *Table 7.14* summarizes the findings.

Table 7.14: Policy-Makers' Rating of Adequacy of Technical Education Facilities in Zimbabwe

	Percentage Rating			
Area	Excellent	Adequate	Inadequate	Grossly
Inadequate				
Number of existing technical training establishments	6.7	26.7	53.3	13.3
Laboratory/ workshop and equipment facilities in the establishment	-	6.7	80.0	13.3
Library facilities	-	-	53.3	46.7
Teaching staff/ Instructors	-	33.3	60.0	6.7

Source: Field Survey, 1998

The table shows that 66.6 percent of the policy-makers found the number of technical training institutions in the country to be inadequate. Also, 93.3 percent of the respondents rated as inadequate laboratory and equipment facilities in these training institutions. All the respondents (100 percent) assessed the library facilities to be inadequate, while about 66.7 percent assessed the teaching staff and instructors to be equally inadequate.

On the issue of funding all the respondents indicated that technical and engineering education in the country had not been adequately funded. Suggestions for improving funding include tapping non-government sources such as from NGOs, industries and parents. Charging students academic fees was also suggested.

The policy-makers' views on funding of technical education are summarized in*Table 7.15.* The table shows that over 93 percent of the policy-makers would want government to favour technical education in their annual budget allocation, as well as in the award of national foreign scholarships. Also, about 93.3 percent would favour granting of bank loans, and the continued disbursement of ZIMDEF special fund to support technical education in the country.

Table 6.15: Policy-makers' views on funding of Technical Education in Zimbabwe

Areas to favour technical education	% Yes	% No
Annual National Budget	93.3	6.7
Disbursement of Government Levy (such as ZIMDEF)	93.3	6.7
Granting of Loans by Banks	93.3	6.7
Award of National Foreign Scholarships	93.3	6.7

Source: Field survey, 1998

Curriculum Structure and Content

Zimbabwe has two faculties of engineering, each offering a different set of engineering programmes as shown below.

University of Zimbabwe (UZ)

The University of Zimbabwe offers four-year Engineering Honours degree programmes (B.Sc. Eng. Hon.) in civil engineering, mechanical engineering, electrical engineering, metallurgical engineering, and mining engineering.

It also offers a Bachelor of Science Surveying honours degree programme that is spread over four years. The entry requirements to the engineering degree programmes include good advanced level passes in mathematics, physics and chemistry plus a minimum of five O'Level passes at Grade C or better in English. Also, A' level passes in technical drawing engineering drawing are acceptable.

The programme is structured into four parts: I, II, III, and IV. All Part I students are required to take and pass in all eight courses. Part I is common to all the engineering Departments and the courses offered are electrical principles, engineering drawing and design, engineering materials, engineering mathematics, computing science for engineers, engineering mechanics, workshop practice and communication skills.

The workshop practice course consists of a continuous assessment of practical work plus a written examination paper. The communication skills course assessment is based on 100 percent course work. Parts II and III are structured such that students are required to take and pass eight courses for each part. In part III, each student is required to undertake a project as well as the Professional Industrial Studies (PIS) course. In Part IV, students are required to take and pass a minimum of four courses from a wide range of options. However, the majority of students generally opt to take six courses. An important requirement of the programme is the industrial attachment whereby each student is required to spend 18 weeks of training with an industrial organization. The industrial attachment is compulsory. The Faculty has an industrial liaison officer who arranges placement of students with industry. The placement is usually done during vacation and the attachment programme is funded by ZIMDEF.

In summary, the structure of the engineering degree programme at the University of Zimbabwe (U.Z) consists of a first year of general preparation of students (Part I, which is common to all engineering departments). This is followed by Parts II, III and IV where students take detailed and specialized engineering courses of lectures, laboratory work, workshops, tutorials and occasional seminars. Practicals and industrial attachment and projects are integral parts of the curriculum. Since 1995, the Department of Mining has been operating a full year of industrial attachment thereby increasing the duration of the programme to five years.

In addition to undergraduate programmes, the faculty recently launched post-graduate degrees and diploma programmes. The post-graduate degrees offered are mainly Master of Science degrees (M.Sc.). The programmes are for two years on a full time basis. They are M.Sc. in Communications Engineering, M.Sc. in Power Engineering, M.Sc. in Renewable Energy and M.Sc. in G.I.S. preceded by Diploma in GIS.

Lastly, Master of Philosophy (M.Phil.) and Doctor of Philosophy (D. Phil) research degree programme have always been offered in the faculty.

National University of Science and Technology (NUST)

The National University of Science and Technology (NUST) was established in 1991 and the Faculty of Industrial Technology launched. The Faculty of Industrial Technology at NUST currently offers five-year degree programmes in electronic engineering, water engineering, and industrial engineering.

At the time of the survey, there were plans to introduce two additional engineering disciplines, chemical engineering and textile technology.

The Bachelor of Engineering programme at the Faculty of Industrial Technology at NUST is a five-year full time honours programme. The programme includes attachment to industry for a period of one year.

The entry requirements are identical to those for the University of Zimbabwe: a minimum of five O'Level passes at grade C or better in English language, plus at least three A'level passes in mathematics, physics and chemistry.

The degree takes five years on a full-time basis. Each year constitutes a part of the degree programme.

Part I is common for all the departments in the faculty and Part IV is the year industry attachment during which period students undertake at least 30 weeks of industrial attachment as part of the degree requirements.

The courses are designed to emphasize both theory and practice. The industrial attachment is designed to provide students with practical knowledge and on-the-field experience. During the attachment, supervising lecturers are expected to visit their students and discuss the progress of their training with their industrial trainers.

Also, each student is expected to undertake some projects as part of the degree requirements. The Part I courses are basic mechanical engineering (2 semesters), engineering drawing (2 semesters), engineering mathematics (2 semesters), fundamentals of civil engineering (2 semesters), work practice and theory (2 semesters) and introduction to computer science (1 semester).

The objectives of the first year courses are to provide the general principles and concepts in engineering. After this first year of grounding, students can take courses in specialized areas as offered in various departments for parts II, III, IV and V.

Besides the specialized engineering courses, the programme allows students to take elective courses. Each student is required to undertake a final year project.

In summary, the engineering honours degree curriculum at NUST has more practical focus, and better industrial exposure than the programmes at the University of Zimbabwe. This is due to the longer period required for industrial attachment under the NUST programme.

Assessment of Curriculum and Course Content

Assessment by Students

A survey involving about 114 students of both the University of Zimbabwe and National University of Science and Technology reveals that about 55.7 percent of the students were satisfied with the way they are trained. About 44.3 percent, however, expressed dissatisfaction with the training. Those who were not satisfied with the curriculum identified such deficiencies as lack of industrial focus, inadequate practicals, inadequate equipment and infrastructure and insufficient library facilities. Students were requested to assess in detail the course structure and course content. The responses obtained are presented in *Table 7.16.*

Table 7.16: Assessments of Curriculum Structure and Course by Engineering Students in Zimbabwe

	Percentage Rating				
Item	Excellent	V. Good	Good	Fair	Poor
Theoretical content	34.8	39.1	21.7	3.5	0.9
Practical content	12.2	16.5	27.0	32.2	12.2
Training techniques	7.0	26.1	36.5	27.8	2.6
Field work	8.0	19.5	27.4	29.2	15.9
Practical projects	11.8	34.5	35.5	15.5	2.7
Variety/range of courses taught	14.0	42.1	38.6	2.6	2.6
Relevance of courses taught	13.0	33.9	40.9	12.7	-
Performance of teachers	6.7	39.0	35.2	17.1	1.9

Source: Field survey 1998

A close look at the table reveals that over 81 percent of the students were satisfied with the performance of their teachers since they rated them to be good to very good. Also rated very highly (94.7 percent good) are the ranges of courses taught under the programme. The theoretical contents of the programme were very well rated, but the practical content was rated to be poor to fair by about 44.4 percent of the respondents. Fieldwork was also poorly rated by about 45.1 percent of the students. The practical projects were, however, rated by about 82 percent to be good to very good.

From the results it is apparent that the practical aspects of the course structure need to be improved. This may involve more work and longer periods for practicals. It may also involve longer periods of industrial attachment particularly under the University of Zimbabwe's programme.

Assessment by Teachers and Trainers

About 59 percent of the trainers considered the current curricula for technical and engineering education to be relevant to national needs and that the curricula prepared the students adequately for future employment. The 41 percent who did not consider the curricula relevant suggested more industrial training and attachment, and more practicals involving the use of more tools and equipment.

Some of the trainers suggested better supervision of students during industrial attachment, while others called for an extension of the industrial attachment period to one year. This is particularly relevant to the programme of the University of Zimbabwe. When trainers were asked about related courses being offered by their institutions about 82 percent identified management courses. Only about 32 percent indicated courses in technology policy; and courses in entrepreneurship development.

These courses could form useful electives in curriculum of engineering students.

With respect to industrial training, approximately 96 percent of the trainers indicated that the students participated in industrial training. Out of this, only about 41 percent participated in the students' supervision. On the usefulness of the industrial training, about 63.6 percent agreed it was useful. Suggestions for improving the industrial training programme include better attitude on the part of industrial employers, better funding and better supervision during the period of industrial attachment.

Assessment by Graduates

About 63 percent of graduates interviewed indicated that they were satisfied with their training. Those who were not satisfied with the training identified poor practicals and inadequate field and industrial experience as the major weakness of the curricula.

An assessment of the curriculum by the graduates is summarized in*Table 7.17.* The table shows that over 84 percent of the graduates were satisfied with the performance of the teachers. Approximately 90 percent were happy with the range of subjects offered, with about 79 percent indicating their satisfaction with the relevance of the subjects offered. More than 94 percent of the graduates were satisfied with the theoretical content of the programme, while about 47.4 percent rated the practical content of the programme as poor to fair. Also, another 47.4 percent rated the training technical as poor. Lastly, fieldwork and practical projects were rated by about 42.1 percent of the graduates to be poor to fair. The practical components of the curriculum were generally assessed by the graduates as not satisfactory.

Table 7.17: Assessment of Curriculum Structure and Content by Engineering Graduates in Zimbabwe

	Percentage Rating				
Item	Excellent	V. good	Good	Fair	Poor
Theoretical contents	36.8	36.8	21.1	5.3	-
Practical contents	5.3	31.6	15.8	36.8	10.5
Training techniques	10.5	15.8	26.3	42.1	5.3
Field work	10.5	15.8	31.6	36.8	5.3
Practical projects	5.3	31.6	21.1	31.6	10.5
Variety/range of courses offered	10.5	36.8	42.1	10.5	-
Relevance of courses offered	10.5	47.4	21.1	15.8	5.3
Performance of teachers	15.8	47.4	2.11	5.8	-

Source: Field survey 1998

The graduates were further asked about the usefulness of their internship training and about 95 percent indicated that they found the internship training very useful. The graduates offered the following suggestions for improving industrial attachment: more and better supervision of students, longer periods of internship and direct payment of students by the ministry.

It should be noted also that both the students and graduates consistently rated the calibre of staff as very good.

Assessment by Employers and Supervisors

Although the employers did not give specific comments on the structure and content on the existing engineering programme, we can infer their assessment from comments that they made on the performance of the graduates they work with. The employers commented that the engineering graduates are well grounded in theoretical knowledge but they often lack practical exposure to industry. In order to improve the current curriculum, more time must be devoted to the industrial exposure of students.

Assessment by Policy-Makers

When policy-makers were asked to assess the relevance of the current curricula (at various levels) to the country's needs, about 26.7 percent said the curricula were relevant to the country's needs. However, a large proportion of the policy-makers (66.7 percent) said that the curricula were not relevant to the country's needs. About 6.7 percent offered no opinion.

The policy makers were further asked to identify what they considered relevant and they mentioned the need for the curricula to be more practical in orientation. Longer industrial training periods, and new courses that have industrial relevance should be introduced. Also, new engineering courses (e.g. courses in food technology and courses in architecture) should be introduced into university curriculum.

Post-Qualification Training and Performance

Many newly recruited graduate engineers are usually given some post-qualification training by the employers. These training programmes are usually designed to improve their on-the-job performance by improving their technical and managerial competence.

The training can be in-house or it can be arranged with other organizations within Zimbabwe. It can also be arranged with an organization outside the country.

The objectives of the training are usually varied. For the newly recruited graduates, orientation can be arranged to familiarise the new officers with the operating procedures of the organization. The training can also be designed to improve the management skills of the newly recruited graduates.

Lastly, training can be designed to upgrade the technical competence of the existing staff; for instance in handling new operational systems within the organization. The period of training may vary from two weeks to about two years depending on the objectives of the training. Some companies have in-house training schools where they provide periodic training to their newly recruited staff or train staff who need to upgrade their professional, technical and managerial skills. In some cases, engineer graduates may be employed to function in new areas of business (such as sales manager for engineering firms). In such positions, they may have to undergo special training in product sales management to enhance their on-the-job-performance.

In summary, post qualification training is an important strategy of improving on the job performance of graduate engineers. Some of the graduate engineers may need the post qualification training to broaden their professional experience and improve their technical competence. They may also need the training to upgrade their managerial skills and thus improve on-the-job performance.

Assessment of Post-Qualification Training and Performance

The report here will focus on the responses obtained from our field survey among graduates and employers in Zimbabwe.

Assessment by Graduates

Out of the 19 graduate engineers interviewed, 68.4 percent said their technical training was adequate for their current job. However, about 68 percent indicated that they had received some additional training from their employers before starting their job. This is a clear indication that majority of the employers do undertake post qualification training for newly recruited graduate engineers.

The type of post qualification training is on-the-job training for one to two years. In fact, some of the graduates were employed as trainees for one year before they became officers or managers. A few graduates (about 18.2 percent) were, however, given some on-the-job training for a period of less than three months. Most of the training is technical in nature, while an insignificant proportion (10.6 percent) is non-technical.

Approximately 73.7 percent of the graduates interviewed indicated that they were satisfied with their present job. Those who were not satisfied (26.3 percent) cited poor remuneration and poor work environment as the major reasons for their dissatisfaction. Only 47.4 percent of the graduates agreed that their monthly pay was commensurate with their training and experience. About 52.6 percent were of a contrary view. In our effort to assess how the engineering training prepares the graduates for their present jobs, the graduates were requested to rate their performance by looking at some specific job factors. The responses obtained are presented in *Table 7.18.*

Table 7.18: Assessment of Post-Qualification Training and Performance by Engineering Graduates in Zimbabwe*

	Performance rating %				
Item	V. well	Well	Fairly well	Poorly	V. Poorly
Application of knowledge	15.8	42.1	42.1	-	-
Work responsibility	15.8	57.9	15.8	10.5	-
Career development	15.8	42.1	31.6	10.5	-
Job challenges	5.3	47.4	42.1	5.3	-
Job security	15.8	42.1	21.1	21.1	-
Use of initiatives	36.8	26.3	26.3	10.5	-
Creativity	26.3	36.8	15.8	21.1	-
Use of tools/equipment	5.3	15.8	47.4	26.3	5.3

* (Q: How well did your training prepare you for your present job? Respondents answer as rated)
Source: Field survey 1998

It can be observed from the table that most of the graduates confirmed that their technical training prepared them (fairly well to very well) for their present jobs in terms of applicationof technical knowledge, work responsibility, career development, job challenges, job security, creativity and use of initiatives. However, about 31.6 percent of the graduates indicated that their training prepared them poorly with respect to use of tools and equipment.

The graduates were further requested to assess how their technical education had affected aspects of their jobs specifically with respect to job opportunities, monetary gains, promotion, work performance, marketability, job satisfaction and professional advancement. The responses obtained are summarized in *Table 7.19.*

Table 7.19: Graduates Assessment of how Technical Education Enhances aspects of their Jobs in Zimbabwe

	Percentage of respondents	
Item	Yes	No
Job opportunities	84.2	15.8
Monetary gains	73.7	26.3
Professional Advancement	73.7	26.3
Promotion prospects	73.7	26.3
Performance at work	94.7	5.3
Job satisfaction	73.7	26.3
Marketability	84.2	15.8

Source: Field survey 1998

It can be seen from the table that 94.7 percent of the graduates indicated that their technical education had substantially enhanced their performance at work. About 84.2 percent confirmed that their technical training has enhanced their marketability and job opportunities while 73.7 percent indicated that their technical education had enhanced their professional advancement, monetary gains, job satisfaction and promotion prospects.

Assessment by Employers and Supervisors

Most of the respondents interviewed were in senior management positions. The establishments they represented are all technical and the number of employees for the companies varied from 65 to 1360. Females represented only seven percent of the total number of employees and all the technical staff had been recruited through advertisement. Although only 25 percent of the companies had in-house training schools some of them are planning to set up schools. About 75 percent of the employees interviewed confirmed that their companies usually provide post qualification training to newly recruited engineering graduates. The companies do this through in-house training and in other organizations in Zimbabwe. The proportion of the employees trained abroad seemed to vary with each company (i.e. from about two to five percent). The major objectives of the training include the following:

- improving technical competence
- preparing employees for additional assignment
- diversifying employees' experience
- broadening employees' professional conduct
- improving employees managerial skills.

In most cases, on-the-job training is given to employees. All those interviewed had some technical training in various fields of engineering and the highest levels of qualification are M.Sc. and MBA, with the majority having obtained a B.Sc. and HND. The years of professional experience of the supervisors varied from six to 29 while the working experience varied from eight to 30 years. Most of the supervisors had supervisory experience varying from three to 20 years. The number of workers supervised varied from three to 1200.

The Employers and Supervisors were requested to assess the performance of the technical graduates they had supervised. The responses obtained in terms of their ratings are presented in *Table 7.20*.

It can be observed from the table that the majority of the employers and supervisors rated the graduates they had supervised as good to very good in most of the areas which they assessed.

Table 7.20: Employers and Supervisors' Assessment of Engineering Graduates' Job Performance in Zimbabwe

	Employers and Supervisors Rating (%)				
Item	Excellent	V. Good	Good	Fair	Poor
Technical knowledge	-	75.0	25.0	-	-
Non technical knowledge	-	25.0	50.0	25.0	-
Performance on the job	-	25.0	50.0	25.0	-
Practical knowledge	-	25.0	75.0	-	-
Initiative	-	25.0	75.0	-	-
Respect for authority	25.0	50.0	25.0	-	-
Willingness to accept responsibility	-	75.0	25.0	-	-
Ability to adjust working environment	-	50.0	50.0	-	-
Innovation	-	-	75.0	25.0	-
Working relationship with others	-	100.0	-	-	-

Source: Field survey 1998

Employees were further requested to assess the products of the various technical institutions in the country based own their own assessment of the job performance of the various products of these institutions. *Table 7.21* summarizes their responses.

Table 7.21: Employers' Rating of Products of Technical Education in Zimbabwe (based on performance on the job)

	Employers/Supervisors Rating (%)					
Item	Excellent	V. Good	Good	Fair	Poor	Main reasons for rating
Vocational training	-	50.0	25.0	25.0	-	Good theory but only fair in practical
Technical colleges and polytechnics	-	50.0	25.0	25.0	-	Have a lot of practicals and fit very well
Universities	-	25.0	75.0	-	-	Well trained but often lack practical exposure to industry

Source: Field survey 1998

It can be seen from the data in *Table 7.21* that most of the employers (75 percent) rated the products of vocational training schools and polytechnics and technical colleges as good to very good. However, 25 percent of the employers rated these products as fair. The basis for the above rating is that products of vocational training schools appear to be good in theory and fair in practicals while products of technical colleges and polytechnics seem to have more practicals and therefore fit well into their jobs.

All the employers (100 percent) rated the products of the universities as good to very good. However, some of the employers indicated that the university products are well trained but some of them often lack practical exposure to industry. The above viewpoints are important in improving the current university curricula.

Female Engineering and Technical Education

Employers of engineering graduates usually require them to have the following attributes:

- excellent background in mathematics and computer science
- deep knowledge of English and preferably one other language
- good understanding of the problems of social sciences and environmental issues
- basic skills in engineering, both through training in the university and in industry
- understanding of basics of management
- ability to communicate and relate to people of all backgrounds.

A close look at the above attributes of the good engineer will reveal that none of them of them is gender biased. Why then will some people regard engineering profession as a male profession? Engineering has been a male dominated profession particularly in Africa because of the general socio-cultural bias against education of females on the continent. In Zimbabwe, as in other parts of Africa, there is a social bias against women in certain education disciplines. Some people usually regard women as the weaker sex and thus, not fit for strenuous work. The physical and natural differences between men and women also psychologically divert women from certain technically strenuous professions.

The bias has been noted by the Zimbabwean government and since independence government policy has endeavoured to promote equal educational opportunities for males and females. The policy had, however, not corrected the gender bias in certain spheres of higher education particularly in the areas of science and technology, engineering included.

Table 7.22 shows the gender of the students who graduated at the University of Zimbabwe in June 1995.

It can be observed from the table that female graduates accounted about 26 percent of the total number of graduates for the 1995. This low percentage of females is an indication that the gender bias has not been effectively corrected.

Table 7.22: Females in Engineering Education: University of Zimbabwe Graduation by Faculty and Gender (in June 1995)

Faculty	Males	Females	Total	Female as % of Total
Agriculture	76	25	101	24.8
Arts	213	122	335	36.4
Commerce	111	51	162	31.5
Education	207	70	277	25.3
Engineering	142	7	149	4.7*
Law	38	18	56	32.1
Medicine	112	52	164	31.7
Science	180	45	225	20.0
Social Sciences	322	126	448	28.1
Vet. Science	15	2	17	11.8
Total	1416	518	1934	26.9

* Least percentage recorded
Source: University of Zimbabwe publication 1996

Another important point to note is that in the Engineering Faculty, only 4.7 percent of the graduates were females. This very low percentage is the least of the ten faculties in the university, thus confirming the socio-cultural bias against women in engineering education. females were more in arts, commerce, law and social sciences as compared with engineering, veterinary science and agriculture.

In an effort to remove the above gender bias in female education, the Government of Zimbabwe put in place an affirmative action policy in 1995. Under this policy, government institutions are required to give females their due and equitable roles with regard to all activities in the organizations. The affirmative action policy was therefore used in the admission of undergraduate students at the University of Zimbabwe in 1996.

Using this policy, more females were admitted by lowering their admission cut off points even though other admission requirements were adhered to. In spite of the affirmative action policy, it should be noted that it would take considerable time before the gender imbalance can be corrected particularly in engineering education. A recent survey among the current students in the Faculty of Engineering by this study (covering both University of Zimbabwe and NUST) revealed that out of 116 students randomly selected from the engineering survey, only eight were females. The female proportion of the engineering students was estimated as 6.9 percent. Although this percentage is low, it is still an improvement on the 1995 female engineering graduates which was estimated as only 4.7 percent.

The current policy to encourage enrolment in the university should therefore be pursued more vigorously in science and technology-based faculties, particularly in engineering.

Assessment of Female Engineering and Technical Education

Assessment by Students

Among the 116 engineering students interviewed, 70 were from the University of Zimbabwe, and 46 from the National University of Science and Technology (NUST). Only 6.9 percent of these students were females, thus indicating the current low proportion of females in engineering education in Zimbabwe.

59.3 percent of the students interviewed were of the opinion that females should be encouraged to take up technical careers. The 40.7 percent who were of the contrary opinion indicated that a technical career is too strenuous and too difficult for females.

Also, approximately 34 percent of the students suggested that females should only take up technical careers that are not too strenuous.

When the students were asked whether special incentives should be given to females to take up technical courses, about 18.6 percent said yes, while 81.4 percent said no. The large number of negative responses on special incentives for females reflects the strong viewpoints of the students on the existing government of affirmative action in Zimbabwe.

Those who were in favour of special incentives for females suggested special scholarships (38.1 percent) and lower admission cut-off points (52.4 percent) as well as a combination of the two (9.5 percent).

The majority of the students also confirmed that females are cope as well as males, in engineering.

Assessment by Trainers and Teachers

All the 22 trainers interviewed were of the opinion that females should be encouraged to take up technical careers. The main reasons for this viewpoint are that females are able to cope with the demands of the engineering and that it is fair to give equal opportunities to females in the technical profession.

When the trainers were asked whether females should only take up some technical careers, the majority of them (68.2 percent) said that females should be able to take up all technical careers. Those who recommended special technical careers stressed that females should only take up non-strenuous technical careers without giving examples.

On the issue of special incentives for females, about 59.1 percent of the trainers favoured special incentives and the incentives recommended include special scholarships, admission quota, and lower cut-off admission points.

The majority of the trainers (86.4 percent) said that females can cope equally with males in respect of technical courses. This is because females are just as brilliant as males. Those who believed that females were less able to cope (13.6 percent) stressed that some technical careers may be too strenuous for females.

Assessment by Graduates

47.4 percent of the graduates interviewed expressed the view that females should be encouraged to take up technical careers. However, a larger percentage (52.6 percent) had a contrary opinion as they stressed that engineering is too masculine a field and therefore too difficult for females. Those who expressed the opinion that females should be encouraged indicated that at present females are too few in the engineering profession and that women are equally capable and they should be given equal opportunities with men.

Asked whether females should only take up certain technical careers, the majority of the graduates (63.2 percent) said females should take up all technical careers. Those who indicated that females should take up selected technical careers (36.8 percent) recommended non-strenuous technical and engineering courses such as computer engineering.

On the question of special incentives for females to take up technical careers, the majority of the graduates (84.2 percent) were opposed to special incentives. Only 15.8 percent favoured special incentives for females. The incentives recommended are lower cut-off admission points, and special scholarships for females.

Assessment by Employer and Supervisors

All the employers interviewed were of the opinion that females should be encouraged to take up technical careers. The reasons given for this view include the need to address the gender disparity issue and the fact that women do as well as men in most professions.

About 75 percent of the employers interviewed expressed the view that females should take up all technical careers, while 25 percent expressed the view that females should take up those technical careers with less physical demands. On the issue of incentives, all the employers expressed the view that special incentives should be given to females because they are as intelligent as men, and they can cope well in most situations.

Assessment by Policy-Makers

All the policy makers interviewed indicated that females should be encouraged to take up technical careers. The reasons for this viewpoint include the fact the females are just as good as males and need for equity and balance to be maintained among the population in the country. The majority, 86.7 percent of the policy-makers said that females should take up all technical careers while 13.3 percent said females should take up only such careers as electronic and electrical engineering or computer engineering. On the question of giving special incentives to take up technical careers 66.7 percent of the policy-makers said yes, while 33.3 percent were negative.

Those who supported special incentives recommended use of special scholarships, female admission quota, or a combination of the two. Most of the policy-makers also expressed the view that females are equally able to cope as men in the pursuit of the technical career.

Summary of Conclusion and Policy Recommendations

Summary of Conclusions

(i) Government Policy on Engineering and Technical Education

The current educational policy of Zimbabwe places considerable emphasis on education for production. The emphasis is on production of manpower that would possess skills needed by industry and other sectors of the economy.

The implementation of this policy requires all students to take at least two technical subjects at junior secondary school level while some technical courses are also offered at the ordinary level for senior secondary school students. It also places emphasis on the development of technical colleges and vocational centres, as well as expansion of training opportunities in the area of science and technology at the university level.

The overall goal of the policy is to equip every individual in Zimbabwe to be self-reliant and more productive whether in the formal or informal employment sector of the economy.
The field survey of policy makers, employers, trainers, graduates, and engineering students carried out in this study reveals that the implementation of government policy on technical education had not been fully successful due to problems and constraints, among them the following:

- inadequate funding of the programmes
- inadequate personnel and infrastructures at training institutions
- inadequate industrial experience for trainers
- lack of appreciation of the policy on the part of some policy-makers
- training not geared to meet specific manpower needs of the country.

Suggestions made to improve policy implementation include the need to focus on areas of comparative advantage of the country and training people in these areas. It also calls for the need for technical training institutions to be expanded, while their curriculum should be revised to emphasize practicals. Also, there is need for the universities to be represented in the formulation of technical education policy. Lastly, industries should be consulted in designing national technical education policy. To acquire more funds for policy execution, non-government sources such as Non-Governmental Organizations (NGOs), industries and donors should be encouraged to participate in the programme.

(ii) Resource capacity

Resources required for the implementation of technical education policy funds, staff and students, and facilities (laboratory, workshop, library and equipment). In terms of funding, government is the main source of funding for the two universities that train personnel in the field of engineering education. Over the years, government budgets for the University of Zimbabwe and NUST had increased significantly. The unit cost of training an engineer has been estimated as about $123,578 for the 1993/94 period. When compared with other disciplines, this unit cost of training can be considered to be high when converted to foreign currency. It represents about 30 percent of the cost of training a graduate engineer overseas hence it is cost-effective. At present, funding is still a major constraint on the implementation of technical and engineering programme in Zimbabwe.

Concerning staffing and students enrolment, the University of Zimbabwe is at present relatively well staffed although a vacancy rate of about 12.5 percent exists for academic staff positions at the Faculty of Engineering. Some vacancies also exist for supporting technical staff. In their assessment of staff, the students rated them to be good to very good. Student enrolment in the Faculty of Engineering had increased from less than 200 in 1982 to about 650 in 1994. However, training facilities such as laboratories, workshop equipment and library facilities have not expanded with the increase in student enrolment. The net result is that the training programme has not been very adequate with respect to facilities.

(iii) Course Structure and Content

The University of Zimbabwe offers four-year engineering honours degree programmes in civil engineering, mechanical engineering, electrical engineering, metallurgical engineering and mining engineering. It also offers a Bachelor of Science Surveying honours degree programme which covers a period of four years.

The programme is structured into four parts. Part I is common to all Engineering Departments and here, the basic grounding for engineering principles are taught. Parts II, III and IV cover specialised areas in engineering theories and practice. Eighteen weeks of industrial attachment is a compulsory component of the programme. Other compulsory aspects are a third year and a final year project and Professional and Industrial Studies and Part III.

The National University of Science and Technology currently offers five-year degree programmes in electronic engineering, water engineering and industrial engineering. The courses cover a five-year period. They are structured into five parts with each year constituting a part. Part I is common for all departments in the faculty and during this part, basic engineering courses are offered. A compulsory component of the programme is the industrial attachment which covers a period of at least 30 weeks. Part IV is the industrial attachment year.

Courses and the content emphasise both practical and theoretical considerations of the engineering disciplines. Assessment of the curriculum and course content by students, graduates, employers and trainers reveals that the current curriculum prepares the students very well of theoretical grounds but not too well in practicals. There is a need to have more fieldwork and longer practicals. The industrial focus of the curriculum should increase particularly at the University of Zimbabwe.

(iv) Post Qualification Training and Performance

Many newly recruited graduates in engineering are usually given post-qualification training by their employers. These training programmes are usually designed to improve their on-the-job performance by improving their technical and managerial skills. The training may be in-house or it can be arranged with other organisations within Zimbabwe. It can also be arranged outside the country. Approximately 68 percent of the graduates interviewed indicated that they received some post qualification training from their employers before starting their jobs. With regard to the relevance of their training to job performance, 94.7 percent of the graduates indicated that their technical education had substantially enhanced their performance at work. Their training also enhanced their job opportunities, marketability, monetary gains, job satisfaction and professional advancement. Employers' assessment of the engineering graduates revealed that university trained engineers were found to be very good in technical knowledge and job performance. However, the employers suggested the need for more practical exposure of students to industry.

(v) Females in Engineering Education

The number of females in engineering and technical professions in Zimbabwe is very low. This is due largely to the socio-cultural bias against women in engineering disciplines. The bias emanates from the society's perception of women as the weaker sex, and as such, not cut for strenuous jobs and professions such as engineering. As a result of this bias, less than five percent of the Zimbabwean engineer graduates are women.

The Government of Zimbabwe in 1995 embarked upon a policy of affirmative action to redress the gender imbalance in various spheres of the economy. The University of Zimbabwe has since 1996 implemented the affirmative action policy by lowering the admission cut-off points for females particularly in the field of engineering, science and technology. Although policy-makers and employers support the affirmative action programme, it will take a considerable period of time before the gender imbalance in engineering education can be redressed. The problem emanates from the schools, i.e. the catchment area where few females do the appropriate 'A' level subject combination of mathematics, physics and chemistry.

(vi) Main Conclusion

This study has revealed that the current government policy objective of education for development has, to a large extent, not been achieved. There are problems of defective strategy and problems of resource scarcity which hamper full scale implementation. It is important that these problems are resolved as means of developing the required technical skills for the technological development of the country.

Policy Recommendations

Based on results of our field survey, the following policy recommendations are suggested:

i. There is a need to involve all stakeholders in the formation and design of national policy on technical education. Quite often government sets up policy without due consultation with all stakeholders involved. The result is that implementation of such policy becomes hampered. For technical education policy to be successfully implemented, government needs to involve industries, other employers, universities and other stakeholders. This is a necessary condition for successful implementation.

ii The government policy on education for production has not fully succeeded because it fails to introduce technical education at the early stage. There is a need to correct this policy by introducing technical education at the primary school level. This will ensure that the Zimbabwean child grows up with the necessary technical background which can be fully developed at the secondary and tertiary level.

iii. The present technical and engineering education curriculum needs more practicals to make it more relevant to the industrial development of the country. In this direction, there is a need for more industrial focus, and better co-operation between the university and the industry. Also new courses in technical policy and entrepreneurship skills development should be introduced.

iv. The present engineering programme is under-funded hence it is unable to provide adequate facilities such as laboratories, workshops, equipment and adequate technical journals in the university libraries. It is therefore recommended that the government should provide more funds for technical and engineering programmes. Also, other sources of funding should be sought. This can be in form of levies from industries, and donations from NGOs.

v. The industrial attachment programme should be strengthened by extending the period to one year and encouraging joint supervision of students between the university and the industry staff.

vi. Lastly, there is need to encourage more females in engineering and technical education. This can be done through an expansion of the present government policy of affirmative action, and by providing special scholarships for female engineering students.

Chapter Eight

Comparative Evaluation of Engineering Education in Nigeria, Ghana and Zimbabwe

Structure of Education and Engineering Education

Any study on engineering education should take a holistic view of the education system as a whole, since the ability of the student to cope with engineering courses would very much depend on the quality of his education in science subjects at the lower levels.

The education systems in Nigeria and Ghana are very similar. Both operate the 6-3-3-4 system which involves six years of primary education, three years in each junior and senior secondary schools, and at least four years in tertiary education. Zimbabwe has a different system comprising seven years in primary school, two years each in junior and senior secondary schools, two years in advanced level school, and at least four years of university education depending on the course. All three countries have in place a policy which promotes the teaching of science, vocational and technical courses at the secondary level, designed to promote technology culture and prepare the products for careers in science and technology. None of them has been able to operationalize this laudable policy due to lack of the human and financial resources.

Policy on Engineering Education

None of the three countries has any specific policy on engineering education but all of them recognised the flaw in the post-colonial education system which, at best, prepared the products for civil service employment or teaching. Graduates of the system had little skill and many schools did not offer science subjects.

Nigeria was the first to introduce radical reforms in 1977, intended to produce skilled, employable labour. The thrust of the new policy was the introduction of science and technology awareness as early as possible with a view to imparting the much needed technical skills. The main features of the policy are:

- introduction of elementary science and technical course in primary schools.
- introduction of skill-forming technical and vocational courses into the secondary school curriculum.
- establishment of vocational centres and technical colleges for the production of middle level

technical manpower.

Zimbabwe introduced major reforms in the educational system after independence in 1980, the primary objective being to equip every graduate of the secondary education with some technical knowledge. Technical courses including woodwork, metalwork and technical graphics were introduced at the junior secondary school level out of which every student must take at least two courses. Ghana introduced reforms in 1987, the main thrust of which was the introduction of more vocational elements in education.

It was clear from the results of the study that none of the countries has made any significant progress in implementing the policy of practical skill acquisition. The main problems identified were:

- poor funding
- lack of laboratory and workshop facilities
- non-availability of technical teachers.

The primary schools are producing large pools of unemployable graduates, most of who do not proceed beyond primary school. Very few secondary schools have the capacity to teach technical subjects; hence most of the products embark on engineering education at the tertiary level with little or no prior exposure to technology.

One positive effect of government policy on technical education is the proliferation of technical and vocational colleges in the three countries. Zimbabwe has eight technical technical-vocational vocational colleges, Ghana has eight, while Nigeria has nearly 150. However, most of them are not well equipped and the expected strong bias towards practical technology is weak. For the same reason, engineering faculties in the three countries are producing graduates who are poorly exposed to practical work. The problem appears to be more serious in Nigeria because of the number of institutions involved. Whereas Ghana has only one faculty of engineering and Zimbabwe has two, Nigeria has 25 faculties, many of which are poorly staffed and ill-equipped to train development oriented engineers capable of leading the quest for indigenous science and technology capabilities for the development of indigenous technologies, selection, acquisition, adaptation and absorption of appropriate development technologies.

Each of the three countries has policies on engineering education which require exposure to intensive practical work as well as industrial experience. Ghana and Zimbabwe engineering students are required to spend at least three six-week vacation periods on industrial attachment. Students on the B-Tech. Programme at the National University of Technology, Bulawayo, are required to spend one full year in industry before graduation. The Nigerian system requires every engineering student to spend one full semester in industry in the fourth year of the five-year programme, in addition to the usual vacation periods. The industrial attachment programmes in the three countries are funded by government.

Clearly, all the three countries have good policies on engineering and technical education in place. Student population on engineering programmes has increased exponentially but there has been no commensurate increase in training resource capacity to ensure effective teaching and adequate exposure to practical work. There is also a problem with placement and supervision of students on industrial work experience programmes. Employers are not operating as they should on placement and supervision of students. The problem is most serious in Nigeria probably due to the much larger numbers involved.

Resource Capacity for Engineering Education

The human and material resource input is a major determinant of the capacity to train good quality engineers. The three countries have a problem with the provision of adequate resources but Nigeria has the greatest problem.

Financing Engineering Education

Universities in Nigeria source over 90 percent of their funds from government, the balance being mainly from miscellaneous fees paid by students (tuition is free), staff rent, etc. No university has succeeded in generating internally anything near the 10 percent of its total revenue as required by the National Universities Commission and none has received any substantial external grants in the last decade or so. The grants received from government are usually no more than about 30 percent of the budget of the university. The situation in Ghana and Zimbabwe is similar except that the faculties of engineering in the two countries have received in recent times substantial grants from the foreign bodies as UNESCO, ODA, CIDA, USAID, GTZ and the World Bank.

The expenditure on the training of each student engineer in 1994 in the three countries is shown in *Table 8.1*. Nigeria spent only about 10 percent of what Ghana spent, which is in turn less than half of what was spent on each student by Zimbabwe. These figures compare very poorly with the $23,100 spent by the United Kingdom on each student in the same year. The situation has remained fairly stable in Nigeria due to the stable though low value of the local currency against the U.S. Dollar in the last year but it has worsened in Ghana and Zimbabwe due to the rapid fall in the value of the local currency. For example, Ghana spent only $900 on each engineering student in 1998.

Table 8.1: Cost of Training a Student Engineer in 1994 in Nigeria, Ghana and Zimbabwe

Country	Cost/Yr ($)
Nigeria	207
Ghana	2000
Zimbabwe	4507

Student Enrolment

Student enrolment in Nigerian universities has grown at a phenomenal rate in the past decade or so and now stands at about 350,000 for the 36 universities. About half of them are registered on science-based courses and about seven percent on the engineering and technology courses. Ghana's five universities have a total student enrolment of about 25,000 out of which about seven percent are enrolled in engineering and technology courses. The corresponding figures for Zimbabwe are 12,000 and eight percent respectively. The above figures represent only about three engineering and technology student per 10,000 population in Nigeria compared with 0.9 and 0.9 per 10,000 in Ghana and Zimbabwe respectively.

Teaching and Support Staff

The student:academic staff ratio for engineering and technology in Zimbabwe in 1994 was 1:9 but has dropped to 1:10 in 1998 due to resignations of about 16 percent of the staff. The ratio of academic staff to technical staff was 3:2 in 1998. Comparative figures for Ghana in 1998 were 1:18 for student:academic staff and 5:1 for academic:technical staff. In 1994, the average student:academic staff ratio for the 26 Nigerian faculties was 1:26 but this has dropped to 1:28 in 1998 due to further staff resignations, increase in students enrolment and difficulties in recruiting new staff. Only Zimbabwe meets the desirable 1:10 academic staff:student ratio (The National Universities Commission of Nigeria specifies a desirable ratio of 1:9)

It was observed that many of the teaching staff in faculties of engineering in the three countries never has any practical and industrial experience beyond what they had as students. This is a major deficiency which could be corrected by encouraging staff to spend study leave and sabbatical leave and sabbatical leave periods in industry instead of others institutions as most do now. Regular industrial excursions with students would also greatly improve the teaching capacity of staff.

Africa universities are experiencing staff losses and are unable to retain or recruit new staff. In a recent study, Saint (1992) estimated that some 23,000 qualified academic staff are emigrating from Africa each year in search of better working conditions. This estimate does not include emigration of academic staff from the economically impoverished West Africa to some countries in Southern Africa which are still relatively stable. It is estimated that about 10,000 Nigerians are now employed in the United States alone. The widespread acceptance of the capacity loss theory i.e. evidenced by various studies. Saint (1992) stated that:

> Attracting and retaining talented staff has now become the biggest current problem for many African universities. Declining salaries, deteriorating working conditions and increasing numbers of students, sometimes exacerbated by un-supportive political conditions, have prompted many staff to seek a better situation elsewhere. As a result, many universities are left with young, inexperienced and insufficiently trained staff who lack the necessary mentors and role models to guide them. Some universities have recently been forced to curtail enrolment and postpone graduations due to staff shortages.

In a more recent report, Blair, R. and Jordan, J. (1994) made some important conclusions about staff recruitment and retention in some African universities:

- there is an exodus of talent from the universities.
- institutional leaders view capacity loss and an inability to recruit staff as a major problem facing their institution.
- most African universities assess their staffing situation by comparisons between staff-in post and establishment with no analysis of patterns, trends, growth of establishment, or absolute growth in staff numbers.
- the position on ground is worse than reflected by the occupancy statistics since, at any time a fair proportion of the staff-in-post are likely to be absent for a range of reasons - sabbaticals, extended leave of absence, study leave, many of them being "phantom staff with no intention of returning.
- many of the staff-in-post are effectively spending the bulk of their time out of the university, moonlight in a second job or private business in order to earn sufficient income to stay abreast of living costs.
- academic staff are concerned not simply with the quantum of salary, but with its puchasing power.
- the remuneration package is the absolutely crucial component of any staff retention policy.

Table 8.2 shows the ratings of some determinants of the quality of the academic environment in the three countries considered in this study, based on the data obtained in the Saint study.

Table 8.2: Ranking of the Quality of the Academic Environment in some African Universities

	% Ranking item as acceptable or better			
Item	Nigeria	Ghana	Zimbabwe	Botswana
Remuneration	18	22	28	76
Living conditions	22	44	42	82
University facilities	18	34	64	82

Source: Blair and Jordan (1994)

Data for Botswana where academic conditions are considered the best in Africa have been included for comparison. These data agree with the finding of this study that Nigeria fares poorest of the three counties studied in resource capacity for engineering education. These data also explain why there are more Nigerians than indigenes in some departments in the University of Botswana.

Most of the vice-chancellors and deans of faculties of engineering interviewed in this study identified staff recruitment and retention as one of their greatest problems. It is doubtful if this situation can be reversed unless the economies of African countries improve significantly.

Teaching Facilities

The faculty of engineering, University of Zimbabwe, had the best laboratory facilities of all the faculties evaluated in the three countries. The equipment was more modern and fairly adequate in terms of range and quality. The computer-aided learning (CAL) laboratory was unique and was established with assistance from UNESCO, UNDP and CIDA (Appiah, 1989). It is a student learning resource which provides interactive, individualized, self-paced learning, using courseware developed in the university. Faculties are also available for staff to develop CAL courseware and structured texts for students.

Computer-aided learning (CAL) is not a replacement for teaching staff but a formidable complement which:

- facilitates student self-study at an individualized pace
- encourages independence in students
- increases students throughout
- reduces the teaching load and staff:student ratios
- encourages students to study on their own, think for themselves, learn by discovery, and develop intellectual independence.

One major advantage of CAL is the reduction of pressure on teaching staff. The Zimbabwe experiment has been in place for about ten years now. So far, it has concentrated on three basic subjects taken by all engineering students applied mechanics, electrical principles, and strength materials. Although the impact of the project on engineering training at the University of Zimbabwe has not yet been evaluated, the potential benefits outlined above commend it for extension to other institutions in Sub-Saharan Africa. The similarity of curricula in engineering training makes it potentially easy to develop jointly courseware suitable for use in the region. There is also a need to extend the present range of basic engineering courses as well as include other specialized courses.

The University Library at the University of Zimbabwe is well stocked with current books and journals and students have access through the Internet to other regional libraries.

Teaching facilities in Ghana's only faculty of engineering are in a poor state. Classrooms are inadequate, most of the laboratory equipment is obsolete and some of it is functioning. The University Library has a fairly good stock of recent books and journals obtained through World Bank assistance which has ceased. However, the Faculty of Engineering, Institute of Mining and Metallurgy both have fairly well stocked libraries.

The state of teaching facilities in engineering faculties in Nigeria is critical. The older faculties have a fairly good range of laboratory equipment but most of it is obsolete or not functioning. The libraries in virtually all the universities have in a depressing state, stocked with obsolete books and journals. In the past few years, some faculties were able to acquire some books and laboratory equipment through World Bank assistance but the facility has ceased. The newer faculties of engineering are in an even worse state since most of them were established when the economy had begun to decline. Most of them have scanty equipment, and some are offering 'alternative to practicals' (there is really no alternative to practicals) courses while others transport students to the older universities for practical courses. The majority of students, graduates and staff interviewed in the three countries did not rate highly the available resource capacity for engineering education, particularly funding, laboratory and library facilities. It is interesting to note that the majority of students in the Nigerian universities studied, rated availability of teachers highly. This is probably because the average teacher in a Nigerian faculty of engineering carries a much heavier load than his counterpart in the other two countries and, despite the staff shortage, classes are usually taught.

Course Structure

There was very little difference in the course structure of engineering faculties in the three countries studied. All were modeled after the British system and many of the staff trained in British institutions. Problems identified by various respondents include:

- inadequate exposure to practical work
- inadequate content of management subjects
- inadequate preparation for the option of self-employment through entrepreneurship education
- inadequate training in writing skills.

A critical appraisal of the engineering curricula in the three countries showed that they were of high standard and had all been accredited by local accreditation bodies. One good measure of the quality of the programmes is the excellent performance of graduates who eventually proceed to postgraduate programmes in the developed countries. One of the deans interviewed provided a long list of graduates of the faculty who had become professors in the United States or were holding senior engineering practice positions in US industries. Another good measure is the generally favourable opinion of employers in the three countries on the capability of locally trained engineers, many of whom are already holding top positions in local industries and engineering consultancy outfits.

A critical look at the curricula of most engineering faculties shows that there is adequate practical content but much of it is not taught because of lack of facilities. Better funding should go a long way in solving this problem therefore.

Although teachers claimed that there was adequate training in entrepreneurial skills, the response by students was on the contrary and there was nothing in the curricula to justify the claim by teachers.

There is a need for a review of the engineering curricula in the three countries to introduce courses in management principles and economics as well as courses in entrepreneurship to introduce students to the option of self-employment. A recent report by the United Nations (1998) was critical of the curricula and orientation of the African education system which makes the products helpless unless they can secure employment. It states:

> It is economically unwise for developing countries to structure their educational systems in a way that school graduates cannot be self-reliant of self-employed but are totally dependent on white collar jobs...

The entrepreneurship courses would not only introduce students to the basic principles and practice, but also expose them to locally feasible projects. Students would also be encouraged to develop their entrepreneurship ideas and possibly try them out while still in college. The establishment of an entrepreneurship incubation centre would greatly facilitate this development. It became clear from interviews that students and staff of engineering departments are not familiar with relevant manufacturing operations of local industries. For example, very few of the students and staff of chemical engineering interviewed in Nigeria had ever been to a cement manufacturing plant despite the fact that at least six plants were in operation in the country, or to any of the many chemical, petroleum or petrochemical plants. Industrial excursions should be formal and an integral part of training in engineering, funded jointly by institutions and parents. They should preferably be scheduled for the final year when students have a good grounding in the theoretical aspects of production.

Post Qualification Training and Performance

Graduates of the engineering programmes interviewed in the three countries were very satisfied with their training and felt that it adequately prepared them for the jobs. Most of them had undergone some on-the-job training. Their only complaint was lack of adequate exposure to practicals while in college. Supervisors and employers were also satisfied with the performance of the graduates on the job. In any case, most of them had training

programmes designed to correct any deficiencies in new recruits as well as focus them on the specific areas of interest to the employers. Their suggestions for improvement include:

- greater exposure to industrial practice during training
- improvement of their communication.

The two suggestions made by employers are important and should be taken into account in the review of curricula. Intensification of the student industrial experience scheme, complemented by structured industrial practice is vital. Courses in technical report writing and communication skills should be introduced in the curricula. The existing curricula emphasize the traditional channels of communication of the engineering profession engineering drawing and graphics. Graduates, particularly those who go into consulting or postgraduate studies eventually find themselves at a disadvantage when they have to write technical reports. It is gratifying to note that at least one university in Nigeria already offers a course in technical report writing in the fourth year.

Females in Engineering Education

Student graduates, employers and policy makers all agree that females are grossly under-represented in engineering. A summary of the findings from the interviews and literature review is summarized below.

- There is a traditional, socio-cultural belief that engineering tech. is heavy, dirty, masculine, and unsuitable as a career for women.
- Some parents have a patriarchal attitude and actively discourage their daughters from enrolling on engineering/technology courses. They perceive the study of mathematics and science as likely to make their daughter 'abnormal' and as not conducive to making them good wives (O'Connor, 1997).
- At the secondary school level, girls shy away from taking science, mathematics and technology (SMT) courses, which are prerequisites for an engineering and technology career because of taunting and discouraging remarks by their male colleagues. In some African countries, they are referred to as witches and he-women.
- Teachers actively discourage girls from SMT courses to save them from embarrassment.
- Girls have been conditioned to feel intellectually inferior to their male colleagues.
- Girls have been known to out-perform their male colleagues in virtually all areas of specialization in engineering and technology, including mechanical, civil computer, and electronic and electrical engineering.
- Most of the interview respondents believe that girls should be encouraged to take up careers in engineering and technology.
- Very few believe in the introduction of special cut-off points to facilitate admission of females to engineering courses.
- Most respondents agree that there should be quota for admission of females to engineering and technical courses and there should also be special scholarships for them.

From the foregoing, it seems clear that the secondary school level is the most important stage that determines whether or not a girl decides to take up a technical career. This is where any measures designed to encourage women can have the greatest impact. Teachers need to be sensitized to the special handicap, difficulties and socio-cultural barriers that girls face in the learning of SMT subjects.

Counselling at the secondary school level could also help in improving the gross imbalance in male-female engineering education. Girls need to be assisted to build up self-confidence and reject harmful socio-cultural beliefs about women who opt for science and technical courses and careers. Use of role model females who have been successful in technical careers - should also greatly assist counsellors in eradicating prejudices and reluctance of girls to take up technical careers.

Technical Education and the Labour Market

The development of a good technical education policy should ideally be based on reliable data on the dynamics of the labour market in which the products will be employed. It is important to know the current and projected demand for technical graduates in terms of numbers as well as skills mix. Apparently, there has been no systematic study of the labour market in Nigeria and Ghana. On the other hand, Zimbabwe has detailed data, which show the demand for trained technical manpower (technical and vocational), as well as projections of requirements into the 1990s (ESARUP, 1993). Zimbabwe also has comprehensive supply and demand data on engineers, classified on the basis of specialization.

The current high unemployment rate among engineers and technologists in Nigeria is due mainly to the implementation of a technical education policy that was not based on any reliable demand-supply data. Federal and State governments can set up, and have in fact set up, tertiary level technical training institutions without any hindrance. The only control measures in place are standards through accreditation by the appropriate bodies. This explains why the country has ended up with about 150 technical colleges and polytechnics and 25 university faculties of engineering. By contrast, unemployment among technical graduates is low in Ghana and Zimbabwe due to a centrally controlled development strategy for technical education planning. Zimbabwe also has an added advantage of a supply-demand database.

There is a school of thought however that technical education and indeed education in general should not be tied to the principles of supply and demand, that the maximum number of potential beneficiaries within the limits of available resources should be given the opportunity, irrespective of the availability or otherwise of job opportunities. There is some merit in this position. Unemployment among educated, skilled, qualified graduates has the potential for promoting entrepreneurship and the option of self-employment. Examples abound of graduates of tertiary institutions who, out of frustration from being unable to secure paid employment, have started businesses which have grown into viable and prosperous businesses. Furthermore, a trained and skilled technologist is not confined to his country of origin and is free to seek employment worldwide. It is estimated that there are almost as many Nigerians and Ghanaian engineers and doctors working in the developed countries as there are in the home countries. A policy of production tied to demand would have denied many of them the opportunity despite their ability. There is also a positive fall-out for developing countries because, some of them, having acquired experience and wealth return to their home countries to set up employment-generating businesses. The United Nations Development Programme (UNDP) recently introduced the TOKTEM project which encourages such professionals to return to their home countries for short periods and assist on development issues. The experience of India is also useful here. The tertiary institutions over the years have produced a very large pool of skilled personnel, much more than the economy could absorb. Many of them are now precious "export commodities" to the developed countries, particularly in the fields of medicine and information technology. Nigeria also has a Technical Aid Corps scheme which involves recruitment of skilled graduates of the tertiary institutions and deployment to other African countries under a technical assistance programme.

Verification of Hypotheses

i) *Engineering education in the selected African countries does not adequately prepare the products for the acquisition of invention, design and production capabilities.*

This study has shown that engineering education in Nigeria, Ghana and Zimbabwe, though sound in theory, does not adequately equip the products with practical knowledge and technological practice which are essential inputs for capacity building in technological acquisition, adoption and adaptation.

ii) *The capacity for training engineering students in the selected universities (funding, staffing, laboratories, workshops etc.) is deficient.*

This hypothesis is confirmed by the results of this study. The capacity for training engineering students in the three countries is deficient. Funding is grossly inadequate, student population is rising at an exponential rate, staff strength is declining at a fast rate, teaching equipment is inadequate and obsolete, laboratory, library and classroom facilities are inadequate.

iii) *The existing curricula in the selected programmes do not promote the culture of entrepreneurship.*

None of the curricula in the engineering programmes evaluated in the three countries offers entrepreneurship education or has any programme which promotes a self-employment culture as an option to paid employment.

iv) *Government policies for training engineers in the selected countries are inadequate.*

Government policies on technical and engineering education in the three countries, although formulated without any reliable planning database are, in fact, adequate. The problem is lack of capacity for implementation.

Chapter Nine

Summary of Conclusions and Recommendations

Conclusions

Based on the findings of this study the following conclusions are made:

i) There is no specific policy on engineering education in any of the three countries studied.

ii) The existing policy on technical education, though not based on any rational study, is comprehensive and, if effected, should be adequate in projecting the three countries on the path of visible development.

iii) None of the three countries has been able to provide the resource capacity to effectively implement most aspects of the existing policy on technical education, but the situation in Zimbabwe is better than in the other two countries.

iv) Faculties of engineering in all the three countries are grossly under-funded and ill-equipped, the situation in Nigeria being the most serious followed by Ghana. The situation in Nigeria is due adequately to the proliferation of faculties 25 compared with one in Ghana, two in Zimbabwe.

v) The engineering curricula in the three countries are structurally similar and are of international standard, but are deficient in practicals, management and entrepreneurship education subjects and graduates lack communication and writing skills.

vi) Under-funding has made it problematic for most faculties of engineering in the three countries to teach the practical content of curricula effectively.

vii) There is little or no interaction between employers and faculties of engineering oncurriculum development or research in any of the three countries.

viii) The student industrial work experience scheme is not working well in any of the three countries mainly because of lack of co-operation by industry in providing appropriate training schedule and supervision.

ix) Graduates of faculties of engineering in the three countries are very satisfied with the training they received and feel adequately prepared for employment careers, but complain of inadequate exposure to practicals.

x) Employers are generally satisfied with the performance of graduates of local faculties of engineering but complain of poor exposure to management subjects and industrial practice in college, and poor writing and communication skills.

xi) Policy-makers admit there is a scarcity of reliable data on which any meaningful policy on technical education could be based. They also admit little or no involvement in curriculum development.

xii) Females are grossly under-represented in engineering education but, from all indications, they are equally competent and often superior to males on engineering courses.

xiii) While such incentives as special scholarships and admission quota should be introduced to encourage females to opt for technical courses, admission cut-off points should not be lowered for them. This is desirable so as not to place females at a psychological disadvantage with respect to their male counterparts. It is difficult however to see how the suggestion of special admission quota can be effected without lowering the cut-of point.

Recommendations

i) There is a need for greatly improved funding for engineering education, considered to be pivotal to economic and industrial development of any nation.

ii) Funding and resource capacity could be greatly improved in Nigeria with fewer faculties of engineering, each designated as a centre of excellence in specific areas of specialization. The example of Zimbabwe is useful. The second faculty of engineering in Bulawayo, which was established in 1991, offers courses which are different from those offered by University of Zimbabwe. One way of improving funding is to introduce academic fees. Zimbabwe has already introduced fees but Ghana and Nigeria have not, although recommendations have been made to both governments. It is difficult to see how any university in the region can continue to provide free qualitative education, considering the decline in economic fortunes of the countries in the region.

iii) The poor teaching staff complement in Nigeria compared with Ghana and Zimbabwe could be improved by rationalization of faculties, and better conditions of service.

iv) The existing policy on engineering education in the three countries, if implemented, would go a long way in stimulating development. The problem has been with the provision of the wherewithal for implementation and the way forward is for each government to provide funds for strengthening the teaching of science, technology and vocational subjects at the secondary school level as well as provision of equipment for practical classes at the tertiary level.

v) The engineering curricula in each country should be restructured to include more subjects on management, entrepreneurship and technical report writing.

vi) It should be mandatory for faculty boards of engineering in each of the three countries to have industrialists as members who should also be invited to participate in curriculum review.

vii) Teachers and trainers should be encouraged and sponsored to spend short periods and sabbatical leave in industry.

viii) Compulsory industrial excursions should be scheduled for the final year by all faculties of engineering and should be a requirement for graduation. Students should be required to pay for such excursions at the beginning of the session and reports emanating from such visits should be graded on a pass or fail basis in the same way student industrial reports are treated in most universities presently.

ix) There should be a mandatory periodic evaluation and review of engineering curricula say every five years, by terms compromising both academics and practicing engineers. This is being done already in Nigeria by both the National Universities Commission (NUC) and Council for Registration of Engineers (COREN).

x) Deans of faculties of engineering should actively encourage departments to foster close relationship with relevant industries. This is the trend in developed countries and substantial funds and equipment often emanate from industry to support research and consultancy problems which are of interest to industry.

xi) The SIWES programme in each country needs to be restructured to ensure better faculty and employer involvement in the design and supervision. Faculties of engineering should have strong industrial placement units, headed by experienced engineers. This is already a requirement stipulated by NUC for every faculty of engineering in Nigeria. There should also be a way of compensating employers for providing placement for students on industrial training. In Zimbabwe, placement of engineering students appears to be relatively easy, but it is problematic in Ghana and Nigeria mainly because employers are reluctant to take students, having paid the mandatory annual tax levied by government for the Students Industrial Work Experience Scheme (SIWES). The problem in Nigeria is exacerbated by the very large number of students who have to be placed each year, compared with relatively few number of suitable industries. Even when students are accepted, they are often not well supervised.

xii) Each of the three countries has a policy on the promotion of female education but there is none in place on female technical education. The major barrier to female education appears to be at the secondary school level and could be reduced through career counseling and by provision of scholarships for females who opt for SMT subjects.

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